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United States Air Force
Center for Environmental Excellence

Environmental Restoration Program

Stage 2
SURFACE BIOVENTING TREATABILITY STUDY WORK PLAN
Draft

April 1993

for
Beale Air Force Base, California
36-35

AQ M01-02-0283

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ENGINEERING-SCIENCE, INC.

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8 April 1993
Ref: NC289.11

Capt. John Coho
AFCEE/ESR
8001 Inner Circle Drive, Suite 2
Brooks Air Force Base, TX 78235-5328

Contract Number: F33 615-90-D-4014
Order Number 002, Modification 02

Subject: Draft Surface Bioventing Treatability Study Workplan

Dear Capt. Coho:

Enclosed is the Draft Workplan for the Surface Bioventing Treatability Study at Beale Air Force Base. This Workplan documents the activities and deliverables associated with 1.3b of the Statement of Work (SOW) for Order 002 Mod 02.

This Workplan will be finalized after we receive your comments. One advanced copy has been sent to Sheri Rolfness (Beale AFB) and a second to Sharon Hrabovsky (MTC). As discussed at the kick-off meeting on February 8th, after your review and approval of the workplan copies should be forwarded to the interested regulatory agencies as soon as possible in order to keep the project on schedule. If you have any questions or need any clarification regarding this submittal, please call.

Very truly yours,

ENGINEERING SCIENCE, INC.

for DKS

Diane K. Spencer, CHMM
Senior Chemical Engineer

Richard S. Makdisi, R.G.
Project Manager

DKS/RSM/amb/38-07.R0

Enclosures

cc: Sheri Rolfness (Beale AFB)
Sharon Hrabovsky (MTC)

Draft

ENVIRONMENTAL RESTORATION PROGRAM
STAGE 2
SURFACE BIOVENTING
TREATABILITY STUDY WORK PLAN

Prepared for the

United States Air Force
Center for Environmental Excellence

April 1993

Prepared by

ENGINEERING-SCIENCE, INC.
PLANNING • DESIGN • CONSTRUCTION MANAGEMENT
1301 MARINA VILLAGE PARKWAY, ALAMEDA, CA 94501 • 510/769-0100
36-35

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

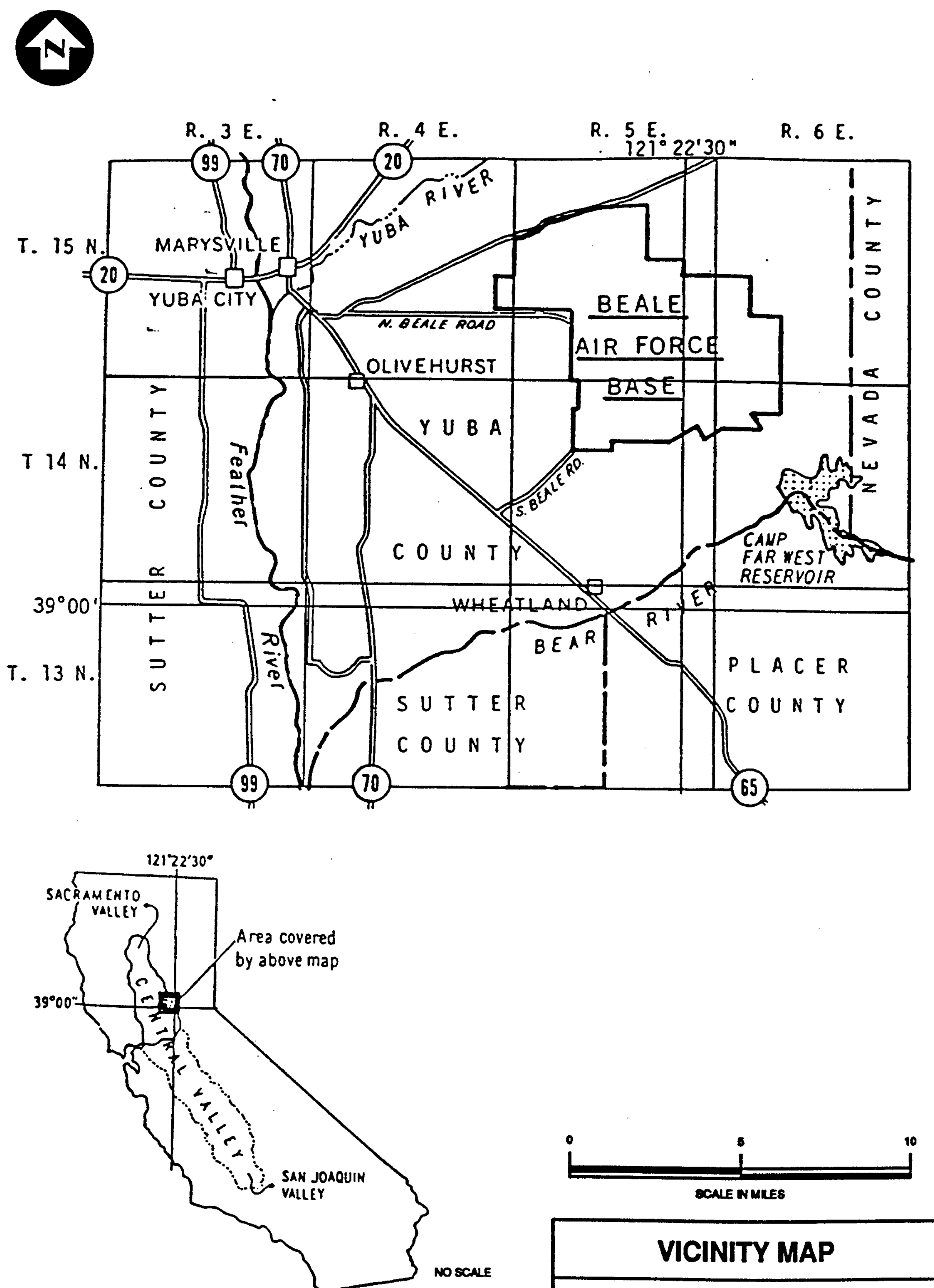
DRAFT SURFACE BIOVENTING TREATABILITY STUDY WORK PLAN
Beale AFB, California

1.0 INTRODUCTION

Beale AFB is located in Yuba County, California, approximately 10 miles east of Marysville and 130 miles northeast of San Francisco. Figures 1 and 2 show the base location map and geography. Beale AFB has accumulated fuel hydrocarbon contaminated soil from underground storage tank removal operations that requires remediation. Engineering-Science, Inc. (ES) has been retained by the Air Force Center for Environmental Excellence (AFCEE) to complete a one-year treatability study on some of this soil at Beale AFB using surface bioventing technology. The first phase of the treatability study will be to complete a short duration pilot test. Based on the pilot test results, a full-scale design will be completed and the soil treatment facility will be operated for one year. This work plan describes both the pilot test and the full-scale treatability study procedures. The treatment process is designed only to treat soils contaminated with total petroleum hydrocarbons (TPH). Precautions should be taken by base personnel to prevent soils contaminated with chlorinated organics, metals, or other contaminants from entering the hydrocarbon soil treatment area. Figure 3 shows the proposed soil treatment area.

Bioremediation has been demonstrated as an effective remediation technology for treating soils contaminated with hydrocarbons. At Beale AFB, three *in situ* soil bioventing systems are currently operating as part of an extended (one-year) treatability study. These systems are successfully treating hydrocarbon contaminated soils similar in composition to those which are currently stored at the soils holding area. There are two elements in the surface bioventing treatability study described in this workplan: the bioventing cells used to treat the contaminated soil and the biofilter used to mitigate emissions. In the bioventing cell, the soil is piled around a piping manifold and air is drawn from the piles in order to aerate the soils. The objective is to treat the soils down to the cleanup level required for disposal of the soil on site. A biofilter composed of biologically active soil will be used to filter the vapor discharge. In the biofilter, the extracted air is blown into a soil pile to reduce hydrocarbon concentrations. Hydrocarbons are removed from the air by adsorption onto the soil and then are broken down through biodegradation.

Contaminated soil treatment at Beale AFB is described in the Soils Management Plan completed by ES under contract with AFCEE (Engineering-Science 1991). Background



SOURCE: GROUNDWATER CONDITIONS AT BEALE AIR FORCE BASE AND VICINITY, CALIFORNIA. U.S. GEOLOGICAL SURVEY OPEN-FILE REPORT 80-204, PAGE, 1980

VICINITY MAP

BEALE AIR FORCE BASE
CALIFORNIA

REV. 1 C251-01.DWG 03/08/93

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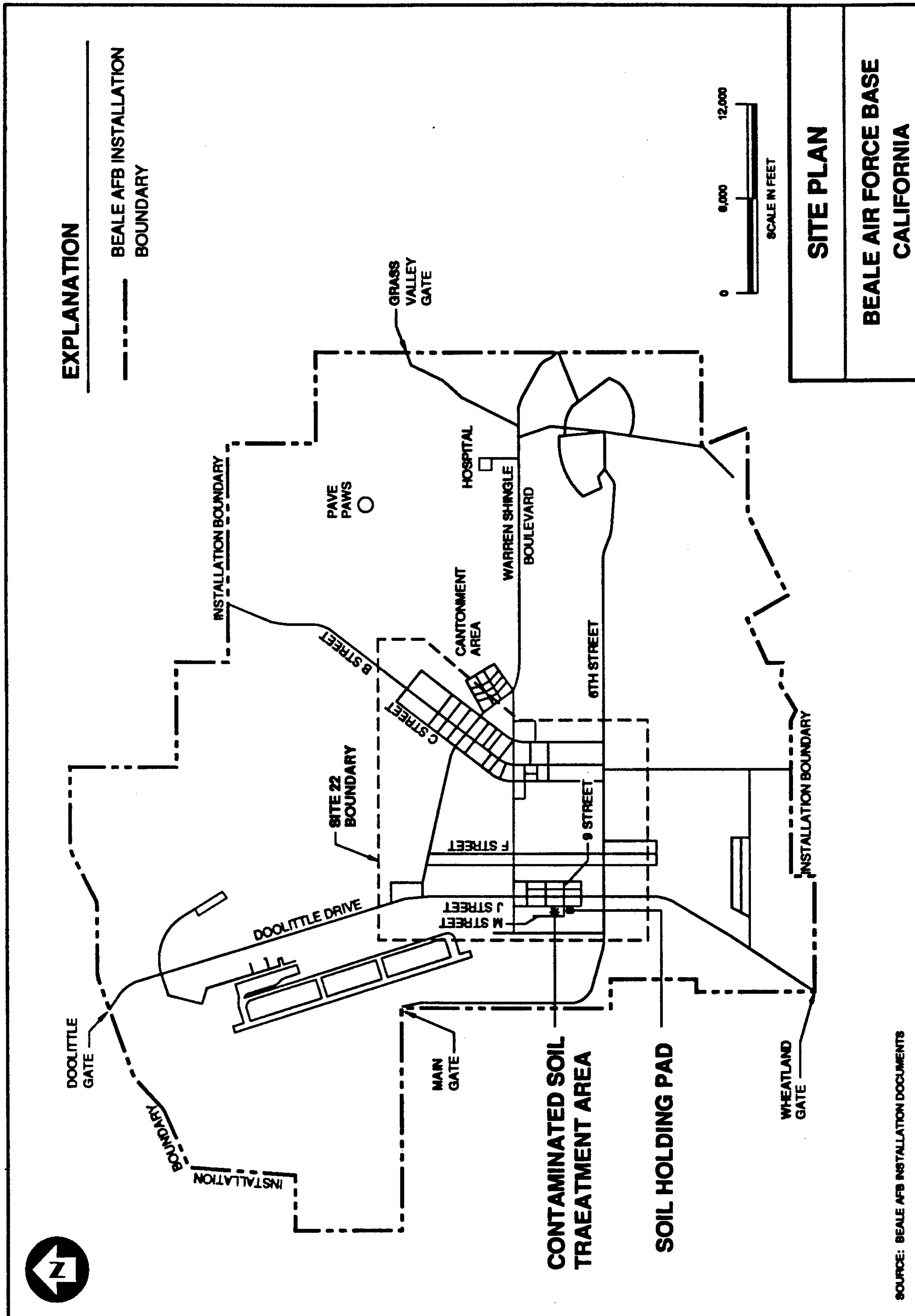
FIGURE 2



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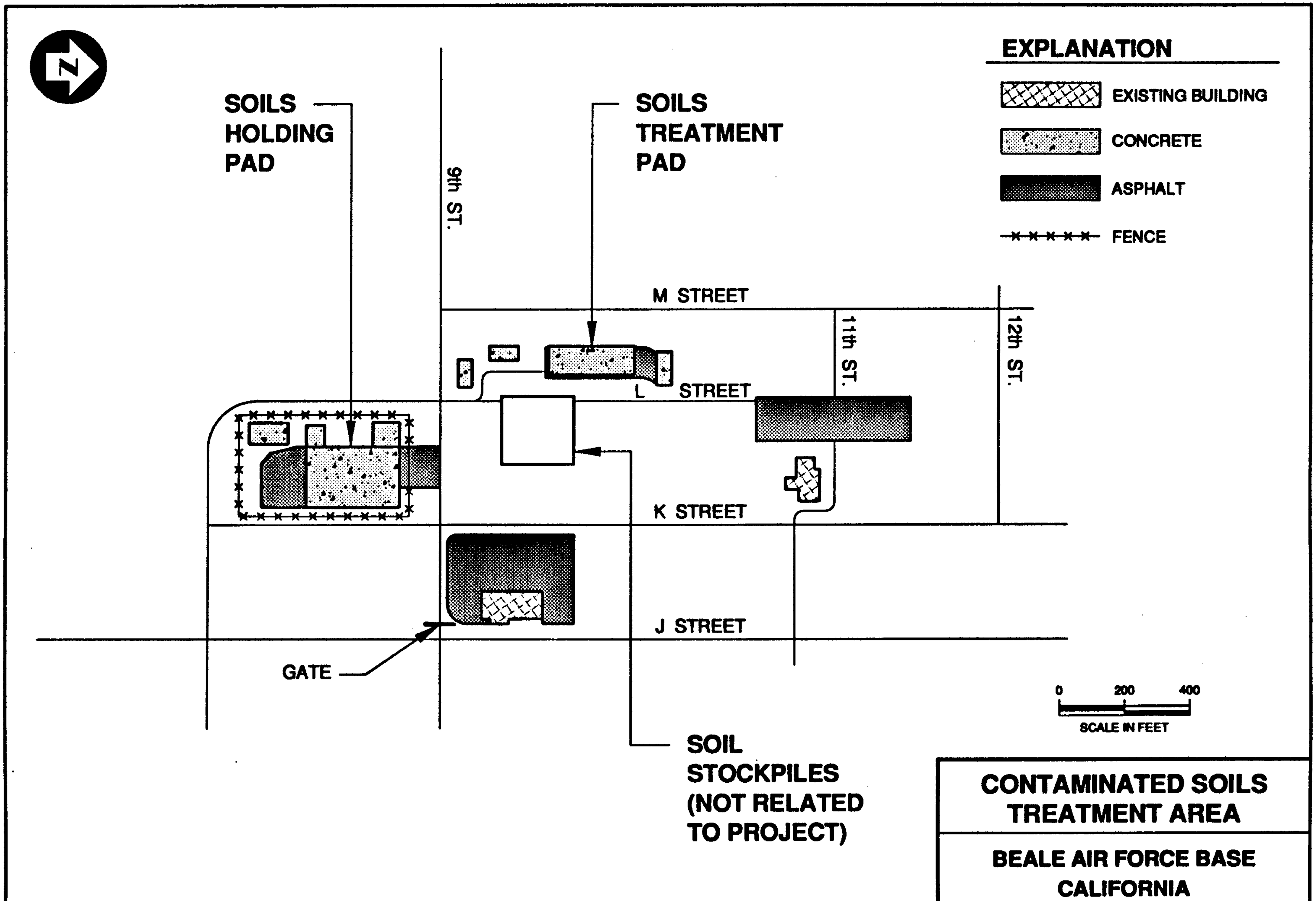

CONTAMINATED SOILS TREATMENT AREA

BEALE AIR FORCE BASE CALIFORNIA

FIGURE 3

REV. 2 C252-03.DWG 03/17/93

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information on the development and recent success of the bioventing technology for *in situ* treatment is found in Appendix A entitled "Test Plan and Technical Protocol for a Field Treatability Test for Bioventing". This protocol document will also serve as an ancillary reference for procedures which will be used during the surface bioventing pilot test and full-scale treatability study. Some exceptions to the protocol are anticipated due to the implementation of a surface bioventing system rather than an *in situ* system. Appendix B contains photodocumentation of existing site conditions. Additional documents associated with this project include the Quality Assurance Program Plan (QAPP) in Appendix C, the Health and Safety Plan (HASP) in Appendix D and the Risk Assessment Results in Appendix E.

Soils mgt Plan

1.1 Objectives and Scope

The objective of this work plan is to present the elements of a one-year treatability study at the soils holding area where the surface bioventing technology will be evaluated. This will be accomplished by a short, two-week pilot test followed by full-scale treatment for a one-year period. The treatability study will test the viability of surface bioventing to reduce TPH concentrations to cleanup goals and to evaluate the biofilter performance.

The key objectives and scope of this treatability study are:

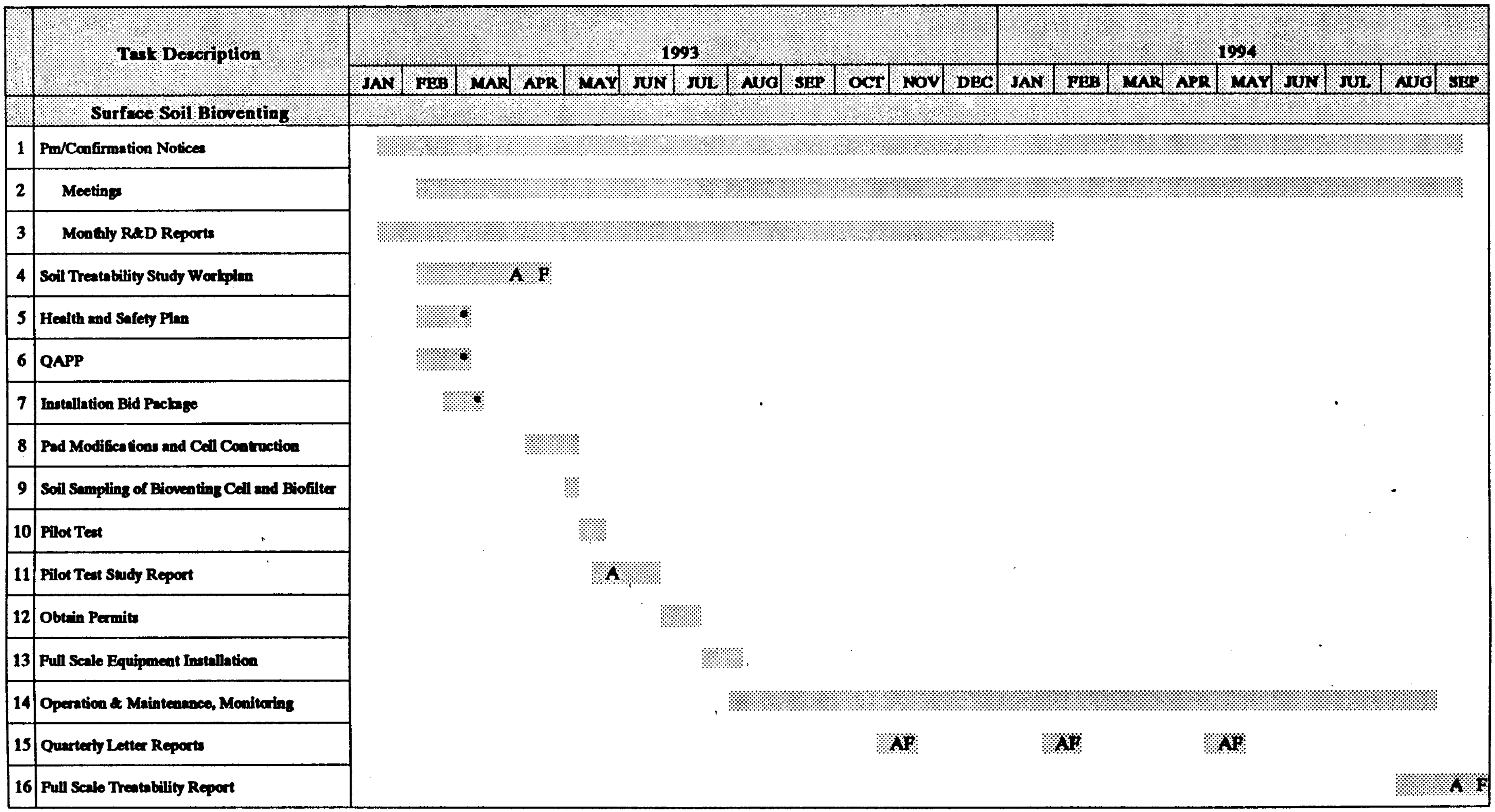
- Gain approval for the treatability study work plan with its bioventing design from all concerned parties.
- Prepare the existing foundation pad for use as a soil treatment pad.
- Determine the initial soil conditions through sampling of a representative bioventing cell and the biofilter.
- Perform a two-week pilot test on a 150 CY bioventing cell composed of TPH contaminated soil, using a 100 CY biofilter to mitigate emissions.
- Assess the pilot test results and make appropriate design modifications as needed for the full-scale treatability study.
- Install, sample, and monitor up to eight additional 150 CY bioventing cells at the treatment pad and modify the biofilter as required.
- Operate the full-scale bioventing system for a one-year period and assess biodegradation rate and volatiles treatment.
- Complete a treatability study report at the end of the year of operation.

1.2 Schedule

The proposed schedule for the treatability study is presented in Figure 4. Adherence to this schedule is dependent upon document review turnaround, permitting, base support in providing electricity and water services, availability of a contractor to modify the pad and construct the soil piles, and the weather. The first two months focus on completing the necessary initial documents such as the Health and Safety Plans, Quality Assurance Project Plan, Treatability Study Work Plan, and the Pad Modification Bid Package.

Figure 4

Project Schedule
Beale Air Force Base
Order 02, Mod 02
ES Project Number NC 289



* = Internal Report Submission

A = Deliverable to AFCEE

F = Final Report

4/07/93

bea_sch3

The treatment pad requires modifications before conducting the pilot test. These modifications are estimated to take approximately one month to complete. During this time the base should have completed the electrical line to the proposed treatment pad. The installation of the 150 CY pilot bioventing cell and biofilter and associated soil sampling to define the initial conditions will take approximately two days. The pilot test will take up to two weeks to complete. After completing an evaluation of the pilot test results, the full-scale system with up to nine bioventing cells will be installed. Evaluation of pilot test results and design modifications will take approximately six weeks. The full-scale blower system and instrumentation can be brought on site and installed within eight weeks following completion of the pilot test and permitting.

The full-scale treatability study will continue until the end of the project. The end of the project is defined to be one year after the full-scale treatability study is begun. The treatment pad is estimated to be of sufficient size to treat 2,500 CY of soil annually. This estimate assumes that the soil cleanup goals will be achieved in 180 days. Pilot testing will provide a more accurate estimate of remediation.

1.3 Bioventing Cell Description

Bioremediation is a process where natural microorganisms in the soil are allowed to degrade the contaminants. The rate of biodegradation within the bioventing cell is dependent on several factors, especially oxygen levels. Aerobic conditions are required for biological degradation of TPH within contaminated soil. Nutrients and moisture also affect biodegradation rates. Except in unusual circumstances, microorganisms that are acclimated to TPH already exist in the contaminated soil and, upon introduction of oxygen, begin to multiply. Soil biodegradation by microorganisms continues until soils meet appropriate cleanup levels. At Beale AFB the cleanup goal for TPH contaminated soil is $\leq$100 mg/kg and $\leq$1 mg/kg for BTEX. Additional details on bioventing principles and operations are included in Appendix A.

Required oxygen levels in the soil pore space for adequate biodegradation of hydrocarbon contaminants is typically 5 percent or greater. The rate at which air is withdrawn from the piles is designed to replenish the oxygen consumed during the degradation process and to maintain an adequate oxygen concentration throughout the soil pile. Oxygen levels are dependent upon the air flowrate, the vent pipe geometry within the bioventing cell, and soil aggregate size and type.

1.4 Biofilter Description

Biofiltering is an emerging technology which uses a biologically active soil or compost pile to control emissions. Off-gas from the bioventing cell is injected into the biofilter soil pile. Contaminants from the emissions first adsorb onto the soil and soil moisture. The adsorption rate depends on several factors including good air distribution, size range of soil aggregates or particles, type of soil, soil moisture and organic content of the soil. Once the contaminant is adsorbed, microorganisms degrade the contaminant. A well designed biofilter relies on balancing and optimizing both adsorption and biodegradation to minimize emissions.

What are the concentr expected to be?

Process conditions for a biofilter are site specific. The residence time required for successful biofiltering depends upon the concentration of volatiles in the feed gas and adsorption rates of the contaminants onto the soil and soil moisture. At higher flow rates the residence time would be shorter given the same volume of biofilter soil. An adequate residence time is when the emissions from the biofilter meet required emissions limits. Research by USEPA on a prototype biofilter used to strip propane and butane from a waste air stream showed 90 percent reduction for a 15 minute residence time (Kampbell et al. 1987).

2.0 SOIL CHARACTERIZATION DATA

2.1 Stockpile Soil Origins

Engineering-Science, Inc. (ES), under the Order 1 contract with AFCEE in 1989 and 1990, removed 21 underground fuel storage tanks (UFSTs) and associated contaminated soil in 1990. Martech USA Inc., under contract with Beale AFB, removed an additional 71 UFSTs in 1992. During the ES investigation, approximately 2,370 CY of contaminated soil was excavated and transported to the soils holding area. During the Martech USA removal operations, approximately 8,560 CY of contaminated soil was added at the soils holding area, resulting in a total estimate of 10,930 CY. The soil pile is currently estimated by Beale AFB personnel to be 12,000 CY to 14,000 CY based on visual screening. The difference in volume is most likely attributed to the normal expansion of the soils after excavation. The ES excavated contaminated soil of 2,370 CY was in-bank volume. It is not known if the Martech USA contaminated soil of 8,560 CY was measured as in-bank or estimated from the volume of surface stockpiles.

Soil sampling results are available from the ES 1990 UFST project and the Martech USA 1992 UFST project. Soil chemistry, however, is not uniform in terms of density of samples per cubic yard, the location of the samples, or the type of analyses. Table 1 shows the available soil chemistry data. The sample density in Table 1 is extreme, ranging from one sample for 1 CY of soil to one sample per 400 CY. The Martech USA data also includes non-detects (ND), presumably from samples collected from the excavation. Appendix B contains photographs showing the stockpile area.

Soil contaminants detected include gasoline, diesel, heating oil, jet fuel, and the component fractions: benzene, toluene, ethylbenzene and xylenes (BTEX). Approximately 5,500 CY of soil contained gasoline at concentrations ranging from 8 to 6,500 mg/kg. Approximately 5,400 CY of soil were contaminated with TPH-d (diesel) at concentrations ranging from 2 to 8,200 mg/kg. TPH-f (jet fuel) was detected at concentrations ranging from 6 to 77 mg/kg in an unspecified volume of soil. Total detected BTEX concentrations ranged from 0.009 to 721 mg/kg and detected benzene concentrations ranged from 0.0007 to 48 mg/kg. As expected, the BTEX components were detected at the highest concentrations in soil contaminated with gasoline.

2.2 Soil Treatment Rationale

Bioventing has been selected as the best available technology for remediating the TPH contaminated soil. Comparisons with other remediation methods such as removal to

TABLE 1
TPH CONTAMINATION
SOIL HOLDING PAD, BEALE AFB

Site	# of Collected Collected	Soil Volume (a) (a)	Soil Chemistry in $\mu g/kg$								Date of Excavation
			TPH Range	TPH Diesel 8015 (Max)	TPH Gasoline 8015 (Max)	TPH 418.1 (Max)	Benzene (Max)	Toluene (Max)	Ethyl Benzene (Max)	Xylenes (total) (Max)	
250	3	5	ND-54,000	5,700	NA	54,000	ND	ND	ND	ND	June 1992
355	6	10	ND-310,000	310,000	NA	15,000	ND	ND	6.8	40	May 1992
440	4	5	ND-46,000	ND	NA	46,000	ND	ND	ND	ND	May 1992
469	4	10	ND-94,000	ND	NA	94,000	ND	ND	ND	ND	May 1992
502	7	15	83,000-2,400,000	240,000	NA	2,400,000	ND	ND	ND	6.2	May 1992
510	4	5	ND-780,000	ND	NA	780,000	ND	ND	ND	ND	May 1992
815	2	5	n.a.	ND	NA	ND	ND	ND	ND	ND	July 1992
1023	2	15	8,000-250,000	250,000	NA	NA	ND	ND	ND	ND	June 1992
1027	6	2,000	4,100-6,700,00	6,700,000	6,500,000	16,000	3,100	3,900	17,000	13000	June/Sept. 1992
1029	2	5	17,000-59,000	59,000	NA	NA	ND	ND	ND	ND	June 1992
1060	2	5	320,000-470,000	470,000	NA	NA	ND	ND	6	45	July 1992
1071	3	5	ND-180,000	180,000	NA	110,000	ND	ND	ND	21	July 1992
1073	1	5	n.a.	ND	NA	NA	ND	ND	ND	ND	July 1992
1077	3	5	140,000-1,000,000	1,000,000	NA	40,000	23	ND	17	50	June 1992
1086	4	15	n.a.	ND	NA	ND	ND	ND	ND	ND	June 1992
1225	16	2000	ND-6,000,000	6,000,000	860,000	84,000	48,000	190,000	83,000	400,000	June 1992
1230	2	5	1,300,000-6,900,000	6,900,000	NA	NA	870	2300	550	3200	June 1992
1240	2	10	170,000-220,000	220,000	NA	NA	ND	ND	50	190	June 1992
1243	4	5	ND-15,000	ND	NA	15,000	ND	ND	ND	ND	June 1992
1319	2	15	37,000-260,000	260,000	NA	NA	ND	ND	ND	ND	July 1992
1320	3	10	3,500-26,000	14,000	NA	26,000	ND	ND	440	1400	June 1992
1322	3	10	2,300-7,800	7,800	NA	NA	ND	ND	ND	ND	NR
JT-1	1	NR	n.a.	6,200	NA	NA	ND	ND	ND	11	April 1992
JT-2	1	NR	n.a.	77,000(b)	NA	NA	ND	ND	ND	ND	April 1992
2161	6	5	ND-2,400,000	2,400,000	NA	2,400,000	ND	9.4	ND	21	May 1992
2172	5	5	36,000-740,000	120,000	NA	740,000	ND	ND	ND	7.7	June 1992
2415	1	0	n.a.	ND	NA	NA	ND	ND	ND	ND	April 1992
2417	3	10	ND-7,200,00	57,000	NA	7,200,000	ND	ND	ND	15	April 1992
2419	2	0	94,000-1,200,000	1,200,000	190,000	NA	ND(c)	710	330	1,800	April 1992
2420	6	10	6,800,000-3,800,000	3,800,000	NA	180,000	120	830	2,000	11,000	April 1992
2431	4	5	ND-1,100,000	1,100,000	NA	460,000	8.7	7.6	ND	9.8	April 1992
2432.1	4	20	n.a.	ND	NA	74,000	ND	ND	ND	ND	April 1992
2432.2	3	5	ND-22,000	ND	NA	22,000	ND	ND	ND	ND	April 1992
2435	2	5	n.a.	ND	NA	NA	ND	ND	ND	ND	June 1992
2439	3	5	4,500-8,200	8,200	NA	59,000	ND	ND	ND	ND	April 1992
2442	4	5	17,000-75,000	75,000	NA	22,000	ND	2.7	21	99	May 1992
2444	4	5	ND-53,000	9,700	NA	53,000	ND	ND	ND	ND	May 1992
2446	5	5	ND-310,000	ND	NA	310,000	ND	ND	ND	ND	May 1992
2453.1	9	25	ND-1,500,000	1,500,000	NA	1,000,000	6.8	640	1,200	3,300	April 1992
2453.2	4	25	ND-1,800,000	1,800,000	NA	1,100,000	730	290	1,200	1,300	April 1992

TABLE 1
TPH CONTAMINATION
SOIL HOLDING PAD, BEALE AFB

Site	# of Collected Collected	Soil Volume (a) (a)	Soil Chemistry in $\mu g/kg$: TPH Range	TPH Diesel 8015 (Max)	TPH Gasoline 8015 (Max)	TPH 418.1 (Max)	Benzene (Max)	Toluene (Max)	Ethyl Benzene (Max)	Xylenes (total) (Max)	Date of Excavation
2458	4	10	ND–100,000	ND	NA	100,000	ND	ND	ND	ND	April 1992
2459	4	10	ND–14,000	ND	NA	14,000	ND	ND	ND	ND	April 1992
2471	5	2,000	ND–2,400,000	2,400,000	NA	37,000	ND	140	490	2,400	April 1992
2472	3	15	ND–34,000	4,900	NA	34,000	ND	ND	ND	ND	April 1992
2474	2	5	n.a.	ND	NA	NA	ND	ND	ND	ND	April 1992
2475	3	5	ND–14,000	ND	NA	14,000	ND	ND	ND	ND	April 1992
2476	3	5	ND–47,000	ND	NA	47,000	ND	ND	ND	ND	April 1992
2477	3	5	ND–24,000	ND	NA	24,000	8.7	ND	ND	ND	April 1992
2489	6	5	3,700–700,000	700,000	8,000	560,000	ND	ND	ND	39	April 1992
2491	4	5	5,000–36,000	5,200	NA	36,000	ND	ND	ND	ND	April 1992
2493	5	10	ND–580,000	580,000	14,000	530,000	ND	ND	17	66	April 1992
2496	7	1,500	ND–640,000	240,000	18,000	640,000	ND(c)	750	170	970	May 1992
2479	6	500	ND–510,000	510,000	NA	68,000	ND	ND	8.6	54	April 1992
2535	2	5	ND–8,000	8,000	NA	NA	ND	ND	ND	5.3	April 1992
2536	2	10	2,000–2,800	2,800	NA	NA	ND	ND	ND	ND	April 1992
2539.1	2	20	2,300–220,000	2,300	NA	22,000	ND	ND	ND	ND	April 1992
2539.2	1	5	ND–2,000	2,000	NA	NA	ND	ND	ND	ND	April 1992
2541	3	5	2,600–30,000	2,600	NA	30,000	ND	ND	ND	ND	April 1992
2548.1	3	50	ND–35,000	35,000	NA	NA	ND	ND	ND	ND	June 1992
2548.2	4	50	ND–26,000	ND	NA	26,000	ND	ND	ND	ND	June 1992
2560	3	30	3,800–170,000	9,700	NA	170,000	ND	ND	ND	ND	April 1992
2696	3	10	2,700–1,200,000	1,200,000	NA	72,000	ND	12	11	200	April 1992
22–A1	5	0	n.a.	ND	ND	NA	ND	120(d)	ND	ND	Oct. 1990
22–A2	5	3	n.a.	ND	ND	NA	ND	36(d)	ND	ND	Sept. 1990
22–A3	9	2	1,500–320,000	320,000	48,000	NA	30	240(d)	23	180	Sept. 1990
22–A4	5	0	59,000	59,000	ND	NA	ND	100(d)	ND	ND	Sept. 1990
22–A5	3	0	n.a.	ND	NA	NA	ND	ND	ND	ND	Oct. 1990
22–A7	2	0	16,000–17,000	17,000	NA	NA	ND	ND	ND	ND	Sept. 1990
22–A8	5	97	38,000–89,000	890,000	NA	NA	0.7	8.5(d)	1.4	ND	Oct. 1990
22–A9	4	14	n.a.	ND	NA	NA	ND	130(d)	0.5	ND	Oct. 1990
22–A10	7	131	45,000–8,200,000	8,200,000	ND	NA	ND	130	ND	ND	Sept. 1990
22–A11	4	351	3,800,000	3,800,000	NA	NA	ND	110(d)	ND	ND	Sept. 1990
22–A12	9	35	320,000–4,100,000	4,100,000	NA	NA	ND	160	780	2,300	Sept. 1990
22–A13	11	896	170,000–1,500,000	1,500,000	NA	NA	ND	120	19	ND	Oct. 1990
22–A14	4	0	n.a.	ND	NA	NA	ND	32(d)	ND	ND	Oct. 1990
22–A15	1	(e)	n.a.	ND	NA	NA	ND	7(d)	ND	ND	Oct. 1990
22–A16	7	139	23,000–810,000	810,000	NA	NA	ND	170(d)	ND	ND	Oct. 1990
22–A17	4	2	24,000–3,400,000	3,400,000	NA	NA	ND	68(d)	ND	8.4	Oct. 1990
22–A18	1	9	36,000–190,000	190,000	NA	NA	ND	140(d)	ND	ND	Oct. 1990
22–A20	9	600	1,100,000–6,900,000	6,900,000	NA	NA	140	1,500	180	16,000	Oct. 1990

TABLE 1
TPH CONTAMINATION
SOIL HOLDING PAD, BEALE AFB

Site	# of Collected Collected	Soil Volume (s) (a)	TPH Range	TPH Diesel 8015 (Max)	TPH Gasoline 8015 (Max)	TPH 418.1 (Max)	Benzene (Max)	Toluene (Max)	Ethyl Benzene (Max)	Xylenes (total) (Max)	Date of Excavation
			Soil Chemistry in $\mu g/kg$								
22–A21	3	80	880,000	880,000	NA	NA	ND	120(d)	ND	9.9	Oct. 1990
22–A22	3	2	n.a.	ND	NA	NA	ND	18(d)	ND	ND	Oct. 1990
22–A25	7	6	120,000–1,700,000	17,000,000	NA	NA	ND	46(d)	ND	ND	Oct. 1990
22–B2	1	2	370,000	370,000	NA	NA	NA	35(d)	NA	NA	Oct. 1990

Notes:

NA = Not Analyzed   n.a. = Not Applicable
ND = Not Detected   NR = Not Recorded
(a) During 1990, soil placed at the soil holding area was screened with a PID.
During 1992, no such protocols are known and therefore soil with ND values may be included.
(b) Motor oil with concentration of 180 mg/kg found in sample.
(c) Detection Limit = 100 due to dilution factor.
(d) Probable false positive for toluene due to use of tape for sealing sample.
(e) Single excavation for 22–A15 and 22–A16.

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03/31/93

landfill, incineration, desorption or soil washing show that biological treatment is the safest, most cost-effective method for achieving compliance with federal EPA and California state cleanup standards (ARARs) and reducing potential future liability to Beale AFB (Engineering-Science 1991). Bioventing was selected over standard landfarming techniques because it allows for biological treatment with significantly less volatile emissions than landfarming in the open air. Biofiltering is included in this treatability study as a potential inexpensive means of further decreasing hydrocarbon emissions during treatment.

3.0 SITE DESCRIPTION AND SOIL PILE CONSTRUCTION

3.1 Site Description

Several cement foundations from former buildings located near the western end of the base may potentially be modified and used as treatment pads. Figure 2 is a site map which shows the location of the pads. Figure 3 shows pads presently being used to stockpile the soil and the pad proposed for treating the soil. Appendix B contains photographs showing the current stockpile area, the proposed treatment pad, and the surrounding landscape.

The area around the cement foundations covers approximately 35 acres and is mostly grass covered open fields, with remnant asphalt parking lots, driveways, and sidewalks. The only occupied structure in the vicinity is the building at K Street and 11th Street. The ground surface is mostly flat except for the areas identified on Figure 3 as the Soil Treatment Pad and Soil Stockpiles, which are approximately 6 feet higher in elevation than the surrounding land surface.

Contaminated soil is currently stockpiled on the 130 ft by 280 ft pad south of 9th Street. Contaminated soil will be treated on the 75-foot by 240-foot pad across 9th Street, between L and M Streets. This pad will be modified to include ramps and 6-inch high berms. The drains and concrete seams will be sealed. A schematic of the pad is shown in Figure 5.

How was this determined?

3.2 Soil Pile Construction

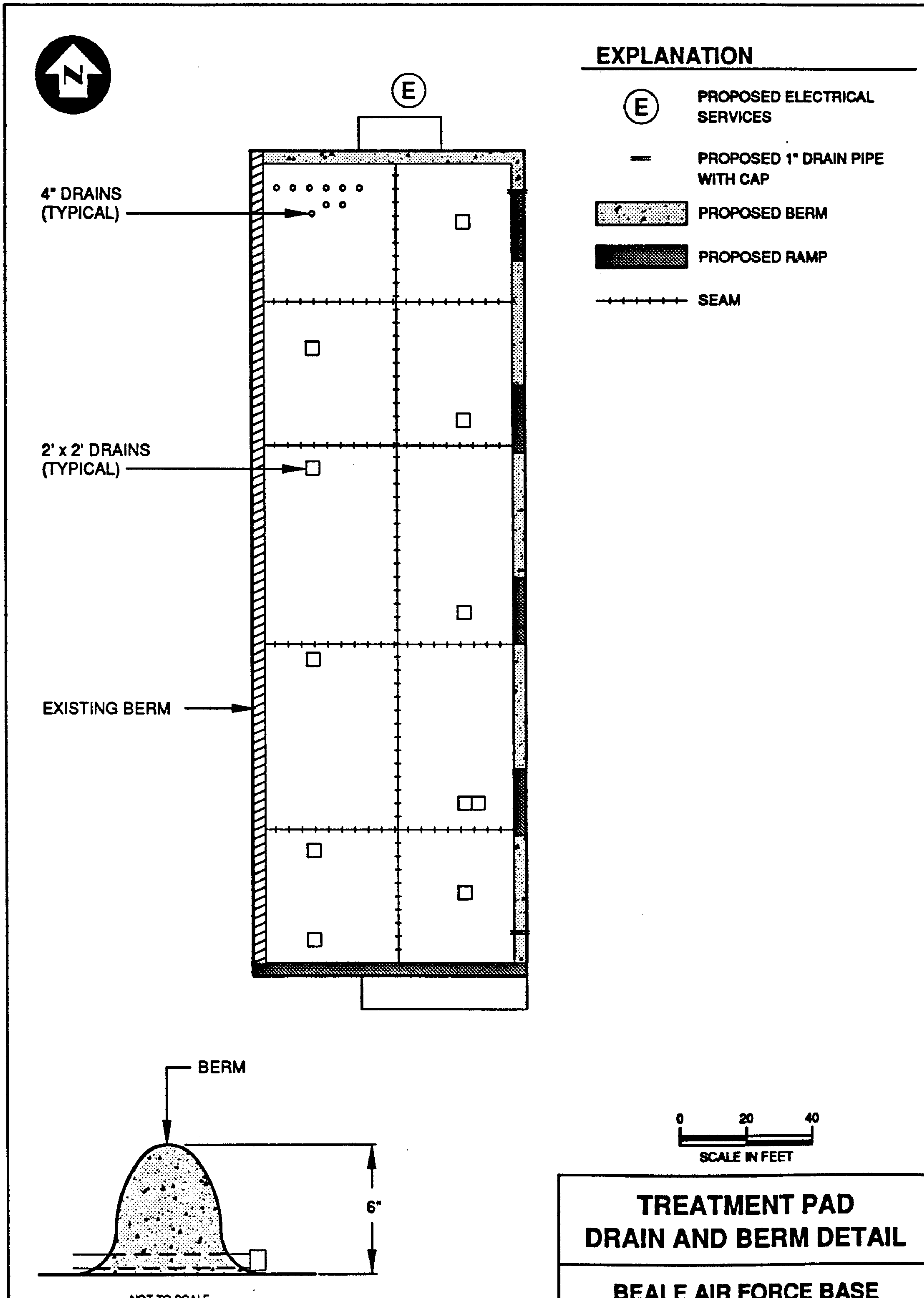
The initial pilot test will consist of one bioventing cell (150 CY) and one biofilter (100 CY) placed on the north half of the treatment pad. The bioventing cell will be 24 feet wide, 55 feet long and 6 feet high. The biofilter will be approximately the same height and with a square configuration about 30 feet long and wide.

Pore volume calculations?

A total of nine bioventing cells are proposed for the full-scale treatability study. The configuration of these soil piles is shown in Figure 6. The bioventing cells and the biofilter will be covered with 20 mil PVC to control volatile organic emissions and prevent leachate formation.

Contaminated soil from the holding pad will be transported to the treatment pad via front end loader and laid out in 1 to 2 foot lifts along the length of the bioventing cell. Soil will be sprayed with water to attain 50 percent saturation. Nutrients will be added to attain a carbon/nitrogen/phosphorous (C:N:P) ratio of 100:5:1 assuming a homogenous

FIGURE 5



TREATMENT PAD
DRAIN AND BERM DETAIL

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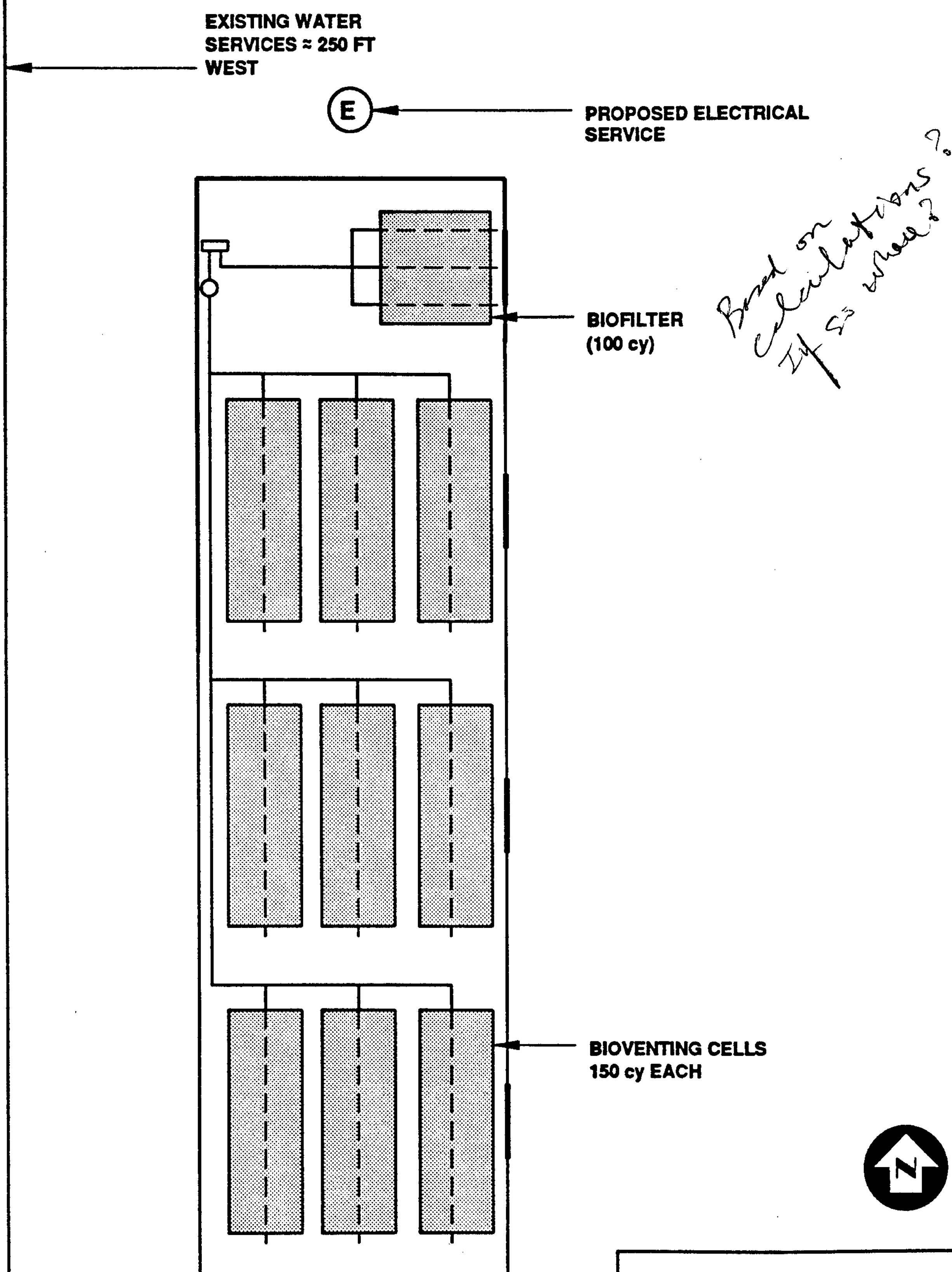

Based on calculations?
If so where?

FULL SCALE SOIL LAYOUT

FULL SCALE TREATABILITY STUDY LAYOUT

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CALIFORNIA**

how many?

initial TPH contaminant level of 1,000 mg/kg. Soil samples will be collected after the soil piles are laid out. The vent pipe will be placed coaxially along the length of the pile about 6 inches from the pad surface. The pipe is 4-inch ID Schedule 40 PVC pipe with 0.04-inch slotted screen wrapped with geotextile. Solid pipe will be used at each end of the pile and will extend about 6 inches to one foot from the pile. The pipe will be wrapped in geotextile. The purpose of the geotextile is to reduce the infiltration of fines into and through the slots. Vacuum gauges will be installed at the far end of the pile, midway, and at the entrance to the pile.

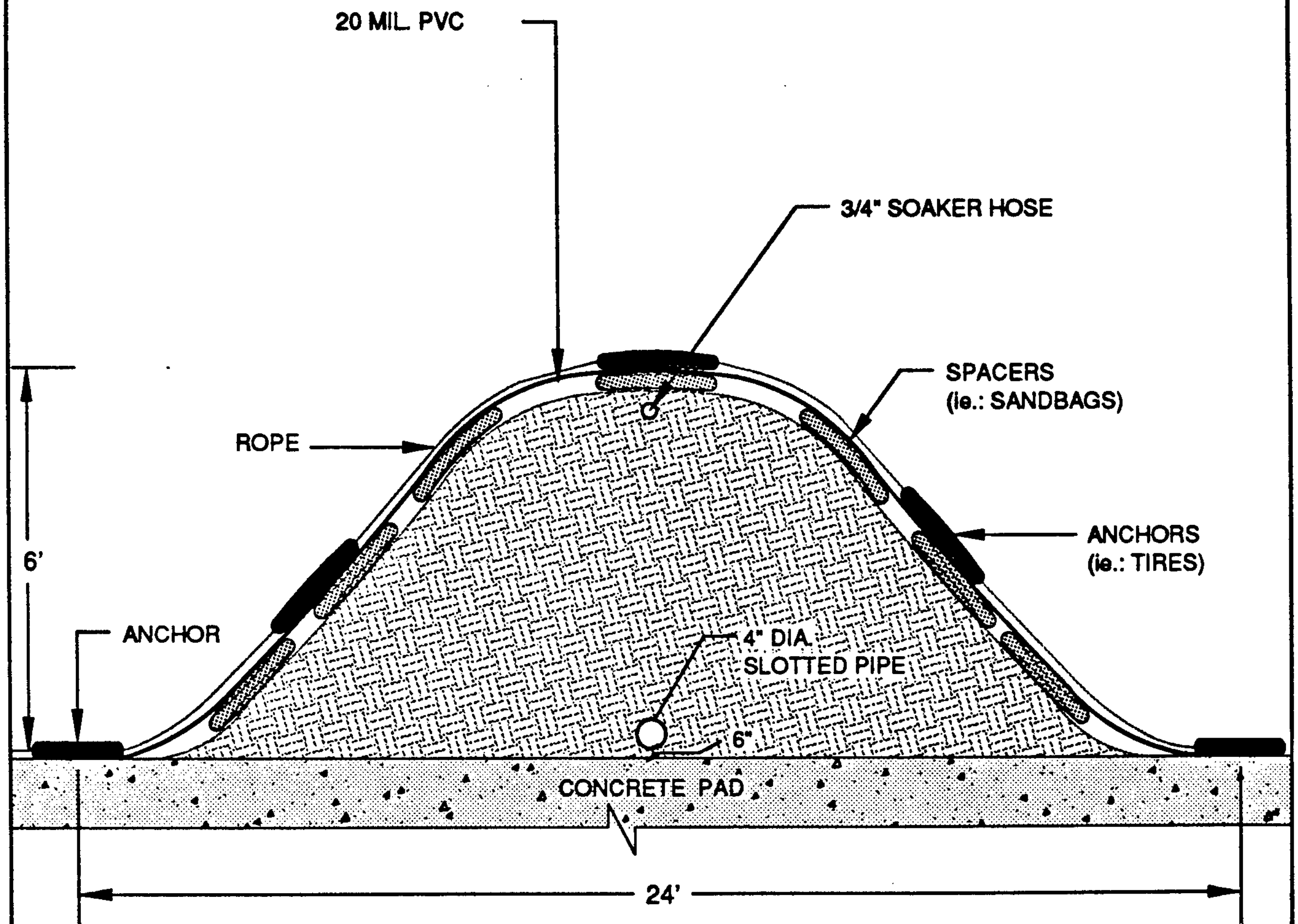
One soaker hose will be laid in a serpentine arrangement along the top of the soil pile. A moisture probe will be used to monitor moisture at different points in the pile. The water flow will be adjusted in order to maintain 10 percent to 50 percent of saturation in the bioventing cell.

Piles will remain covered during the remediation stage. The proposed technique to supply air to the soil is to create air pathways below the tarp by using sand bags as spacers, which will allow air circulation during the treatment process. Tires will be placed on top of the tarp to secure it in place. Figure 7 shows a typical cross section of a bioventing cell.

Three vapor monitoring points will be used on the pilot test bioventing cell, one midway down the length of the pile and one each 10 feet from the ends of the bioventing cell. Vapor Monitoring Points (VMPs) located in the bioventing cell and biofilter will be constructed of 1/4-inch ID Schedule 80 PVC casing, with a 6-inch interval of 1-inch diameter 0.02-inch slotted screen. Screens will be set at two depths: approximately 1 foot above the distribution pipe and 1 foot below the surface. The screens will be wrapped in geotextile or equivalent liner which will prevent soil fines from entering the screen. VMPs will be labeled following procedures outlined in Section 4.2.3 of the Protocol Document (Appendix A).

Approximately 100 CY of soil with a TPH concentration of less than 100 mg/kg will be used to construct the biofilter. The biofilter will be constructed on the north-east corner of the treatment pad. In order to distribute the emissions throughout the biofilter, three 2-inch diameter 0.04-inch slotted distributor pipes will be laid west to east along the length of the biofilter and approximately 7 feet apart. The distributor pipes will be placed approximately 6 inches from the pad surface. Solid pipe will be used at each end of the pile and will project beyond the pile about 6 to 12 inches. A pressure gauge will be installed at the far end of the distributor pipe.

A 4-inch slotted pipe placed coaxially along the top of the soil pile will be used to collect emissions. The east end of the collector pipe will project out of the tarp and will be used to collect emission samples. Two vapor monitoring points will be constructed identically to the vapor monitoring points for the bioventing cell and will be located 10 feet from the west and the east end of the biofilter. A cross section of the biofilter is shown in Figure 8. The volume or configuration of the biofilter may be modified based on pilot test and full-scale treatability study results.



NOT TO SCALE

BIOVENTING CELL CROSS SECTION

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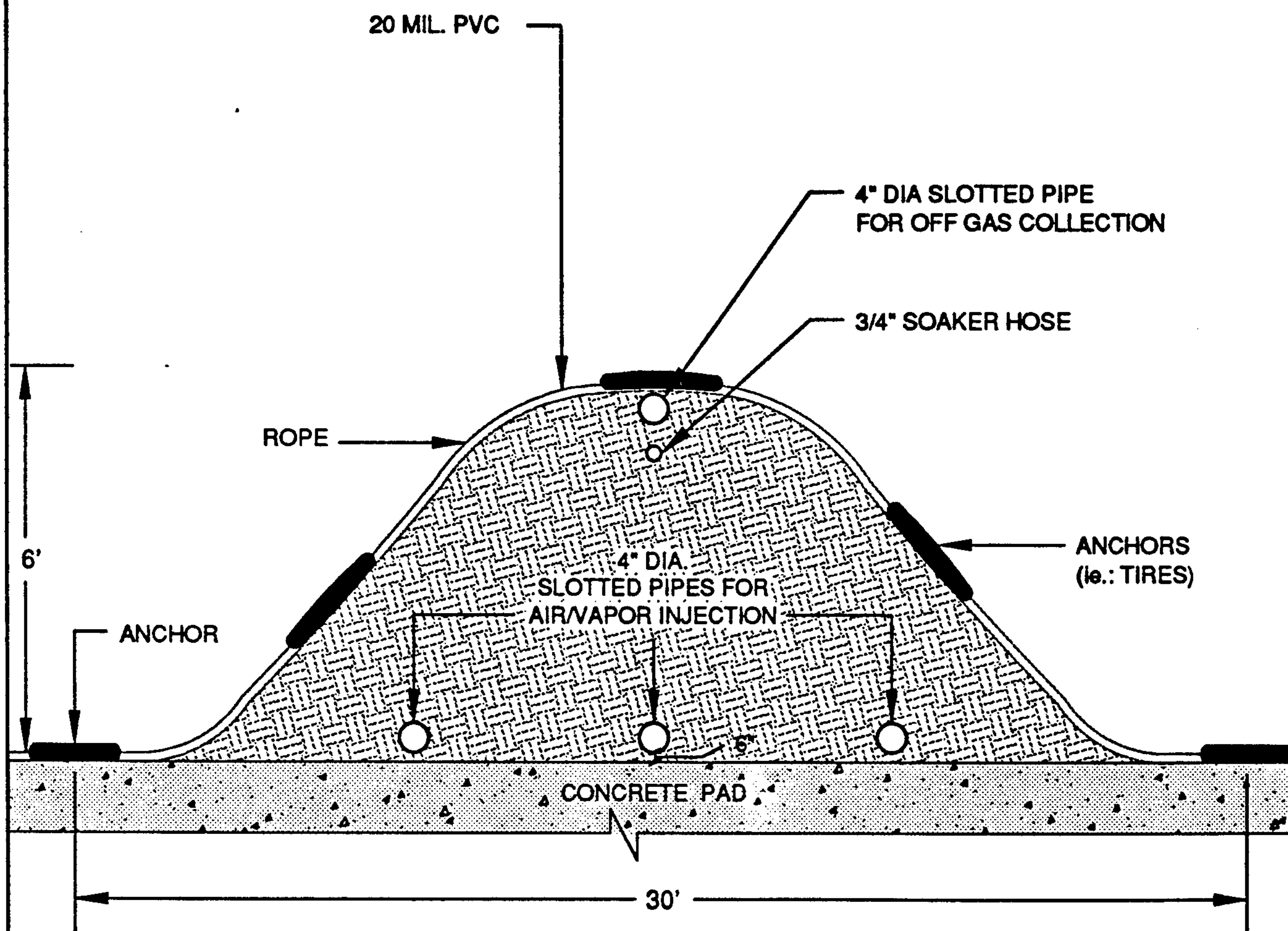

NOT TO SCALE

BIOFILTER CROSS SECTION

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A mechanical plan for the pilot test is shown in Figure 9. The mechanical plan for the full-scale treatability study may be different based on the pilot test.

4.0 PILOT TEST PROCEDURES

4.1 Vapor Monitoring Point Locations

Three vapor monitoring points (VMPs) will be installed in the pilot bioventing cell. VMP-1 will be located 10 feet from the exhaust end of the cell (closest to the blower), VMP-2 will be located near the center of the cell, and VMP-3 will be located 10 feet from the far end of the cell. Each VMP will be screened at two depth intervals: approximately one foot above the vent pipe and one foot below the surface.

Two additional VMPs will be installed in the biofilter. VMP-4 will be located 10 feet from the inlet end of the biofilter (closest to the blower) and VMP-5 will be located 10 feet from the far end of the cell. Each VMP will be screened at two depth intervals: approximately one foot above the distribution pipe and two feet below the surface.

The proposed VMP locations are shown in Figure 9. The six individual monitoring screens in the bioventing cell and the four individual monitoring screens in the biofilter should provide adequate characterization of soil-gas, vacuum, and pressure during the pilot test.

4.2 Initial Soil Sampling

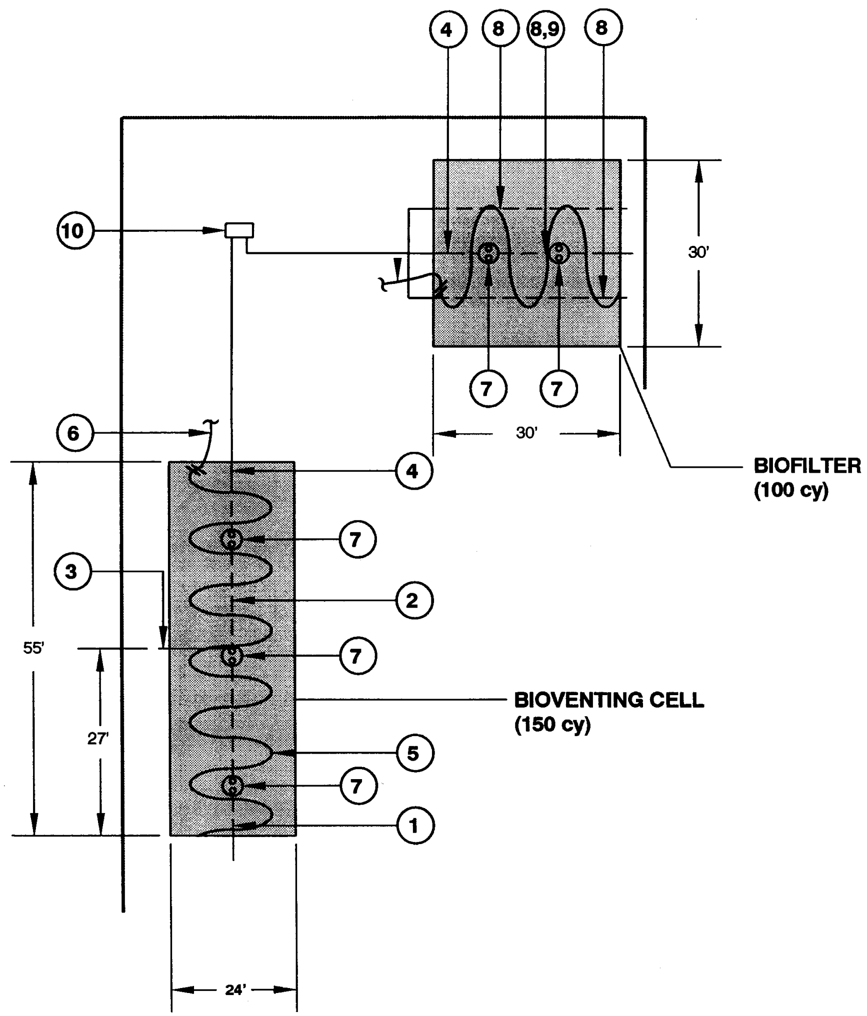
To characterize initial soil conditions in the bioventing cell and biofilter, a minimum of five composite soil samples will be collected, three from the bioventing cell and two from the biofilter. This will provide a sample density of 1 sample per 50 CY of contaminated soil which will meet regulatory requirements and is in conformance with the statement of work. However, a greater sample density such as one sample per 20 cubic yards would enhance the assessment of both the bioventing cells and the biofilter. Each sample will be composited from soil collected with a hand auger from three locations and three depths.

how many

All soil samples will be analyzed for total petroleum hydrocarbons (TPH) using EPA method 8015 and aromatic hydrocarbons including benzene, toluene, ethylbenzene, and total xylenes (BTEX) using EPA method 8020. These analyses are most appropriate for the expected range of gasoline, diesel, and heating oil contamination. In addition, one of the soil samples will be analyzed for soil moisture, pH, grain size distribution, alkalinity, total iron, and nutrients (total Kjeldahl nitrogen and total phosphorus).

Soil samples will be labeled following the nomenclature specified in Section 5 of the Protocol Document (Appendix A), wrapped in plastic, and placed in an ice chest for shipment. A chain-of-custody form will be filled out and the ice chest shipped to a laboratory which has been audited by the U.S. Air Force and meets all quality assurance/quality control and certification requirements for the State of California.

Soil headspace volatiles will also be measured in the field using a photoionization detector (PID) and total hydrocarbon vapor analyzer (THVA). A review of these PID/THVA readings and soil chemistry will be completed to determine if any correlation



PILOT TEST SOIL, PIPE, AND HOSE LAYOUT

EXPLANATION

1. 4" SCH 40 PVC PIPE, NOT SLOTTED, 5' LONG WITH REMOVABLE SOCKET CAP EXTENDS 6" BEYOND SOIL PILE
2. 4" SCH 40 PVC SCREEN, 0.04 SLOT, THREADED (NOT GLUED) WRAPPED IN GEOTEXTILE
3. 1/2" NPT SCH 40 PVC PIPE WITH PLUG (NOT GLUED)
4. 4" SCH 40 PVC PIPE, NOT SLOTTED, 5' LONG EXTENDS 6" TO 1' BEYOND SOIL PILE
5. 5/8" SOAKER HOSE, 80 TO 100 FEET
6. 5/8" FLEXIBLE HOSE, CONNECT TO WATER SERVICES
7. NESTED VAPOR MONITORING POINTS AT 1.5 FEET AND 5 FEET
8. 4" SCH 40 PVC SCREEN, 0.04 SLOT, THREADED (NOT GLUED)
9. 4" SCH 40 PVC SCREEN, 0.04 SLOT, THREADED (NOT GLUED), AT TOP OF SOIL PILE ONE END EXTENDS 6" TO 1' EAST OF SOIL PILE
10. BLOWER SYSTEM AND INSTRUMENTATION

NOTE:
ES WILL INSTALL PROCESS CONNECTIONS BETWEEN THE BIOVENT CELL AND BIOFILTER.

PILOT TEST MECHANICAL PLAN

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exists. However, any correlation would be dependent on the make up of the volatile constituents involved. For example, heating oil which has a low percentage of volatile components may show very little correlation with PID/THVA readings, while soil from a relatively fresh gasoline spill may show a much greater correlation.

4.3 Blower System

A 3.0 horsepower portable, positive displacement blower capable of extracting 30 standard cubic feet per minute (scfm) at 6 inches Hg vacuum will be used to conduct the pilot test. Figure 10 shows a process and instrumentation diagram for the pilot test. A knock out pot will be used to prevent excessive moisture from entering the blower and an air filter will be used to prevent any fine soil particles from entering the blower.

30 cfm

4.4 Oxygen Distribution Test

The objective of the oxygen distribution test is to determine the extent of effective aeration within the bioventing cell and the biofilter. The distribution of oxygen within the bioventing cell and biofilter will be monitored by measuring oxygen levels at all VMPs. Carbon dioxide and volatile hydrocarbon measurements will also be taken simultaneously. Initial oxygen levels are measured in order to verify that active aeration will be required to enhance biodegradation in the bioventing cell. A period of 1 to 3 days after construction of the bioventing cell may be necessary for soil air in the center of the bioventing cell to reach a concentration approaching 0 percent oxygen.

Following initial measurements, the blower will be started and oxygen profile measurements will be performed at intervals of 2 hours, 6 hours, and 24 hours. These intervals may be altered to better characterize the oxygen distribution with time and/or to achieve oxygen levels within the bioventing cell greater than 15 percent. All measurements will be recorded in the field notebook.

What are the rates of air flow?

4.5 Vacuum and Pressure Distribution Test

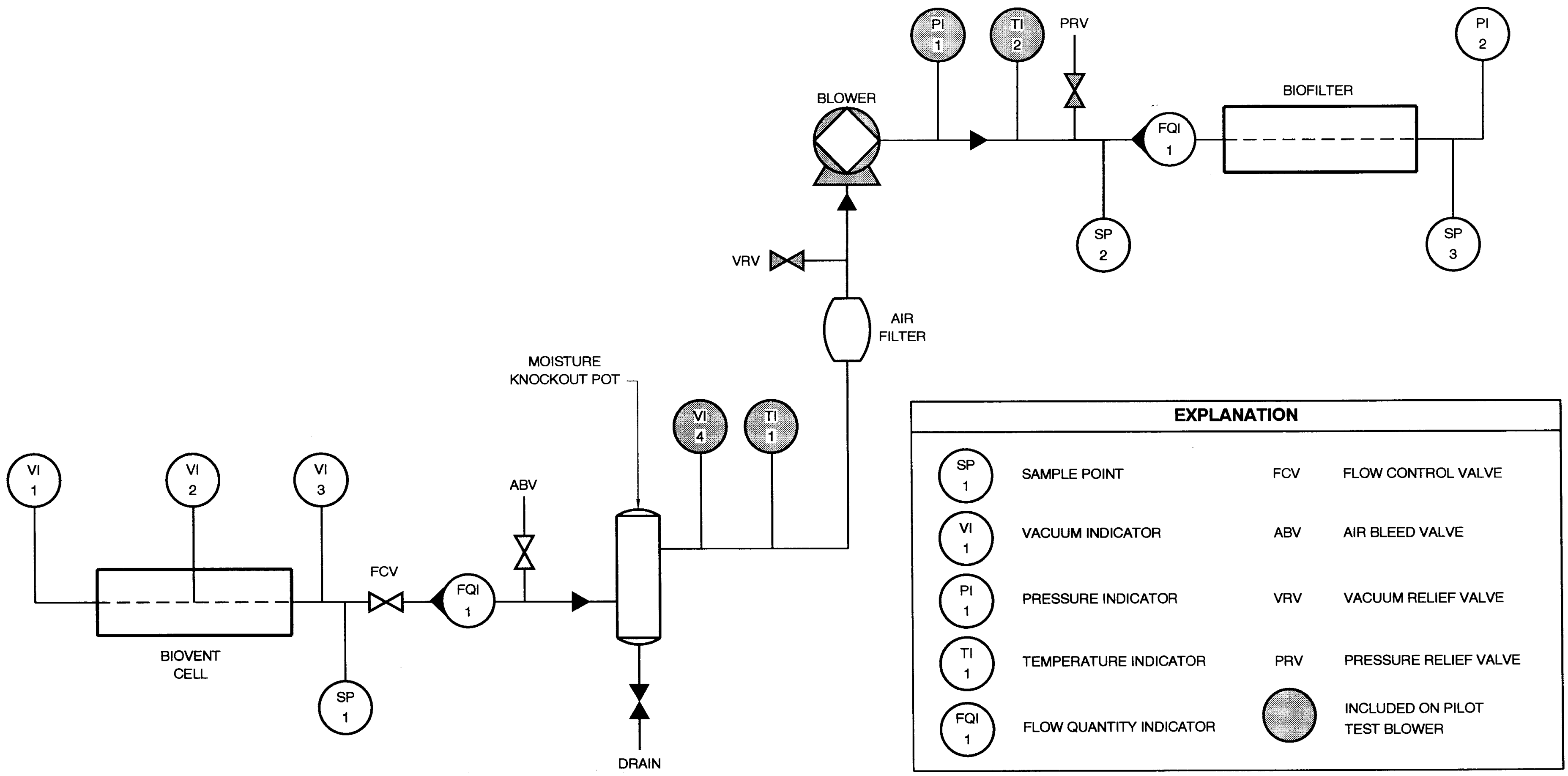
The objective of the vacuum and pressure distribution test is to evaluate the impact of different air flow rates on the vacuum distribution along the length of the vent pipe within the bioventing cell and the pressure distribution along the length of the distribution pipe in the biofilter. This short duration test will be performed upon completion of the oxygen distribution test. Results of this test will also be used to size the blower for the full-scale treatability study.

Vacuum measurements will be taken at the far end of the bioventing cell, midway, and at the entrance to the cell for different air flow rates. Pressure measurements will be taken at the entrance to the biofilter and at the far end of the biofilter. All measurements will be taken using gauges and recorded in the field notebook.

4.6 Respiration Testing

The objective of the respiration test is to determine the rate at which soil bacteria degrade petroleum hydrocarbons. Respiration tests will be performed at all VMP locations within the bioventing cell and biofilter. At the end of the oxygen distribution test, the blower will be shut off. Oxygen and carbon dioxide levels at all VMPs will be

FIGURE 10



SURFACE BIOVENTING PROCESS FLOW AND INSTRUMENTATION DIAGRAM

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measured for 48 to 72 hours, or until oxygen levels fall below 5 percent in the bioventing cell. The decline in oxygen over time will be used to estimate rates of bacterial degradation of fuel residuals in both the bioventing cell and the biofilter. Further details on the respiration test are described in Section 5.7 of the Protocol Document (Appendix A).

4.7 Steady-State Soil Gas Sampling

An additional indicator of biodegradation within the bioventing cells and biofilter is the steady-state depletion of oxygen as it passes through the contaminated soil volume. Although not as reliable of an indicator, carbon dioxide production can also be used to estimate the quantity of hydrocarbons being degraded in the bioventing cells and biofilter especially in a low pH environment. Exhaust air from three sample points will be collected and analyzed for oxygen, carbon dioxide, and volatiles. The sample points are located in the vent pipe exiting the bioventing cell, and in the pipe at the entrance and exit end of the biofilter. A GasTech™ Model 32520X CO_2/O_2 gas analyzer will be used to monitor steady-state gas concentrations exiting the bioventing cells and exiting the biofilter. A GasTech™ Trace-Techtor Total Hydrocarbon Vapor Analyzer (THVA) will also be used to monitor steady-state volatile hydrocarbons.

PID and THVA readings of the air above and around the biofilter will be also be measured to determine if the biofilter is successfully containing the emissions from the bioventing cell. how many & how often (freq)

Exhaust gas samples will also be collected in Summa® cannisters for laboratory analysis of total volatile hydrocarbons (TVH) and BTEX (EPA Method TO-3). Total volatile hydrocarbons and BTEX will be analyzed during the pilot test to determine: 1) the anticipated loading of TVH into the biofilter during full-scale treatment, and 2) the removal efficiency of the biofilter cell at these TVH concentrations. The samples will be placed in a small ice chest and packed to prevent excessive movement during shipment. Samples will not be sent on ice to prevent condensation of hydrocarbons. A chain-of-custody form will be filled out and the ice chest shipped to the Air Toxics Laboratory in Rancho Cordova, California for analysis.

5.0 DATA ANALYSIS AND FULL-SCALE TREATABILITY STUDY

5.1 Data Analysis of Pilot Test

The pilot test results will be used to make appropriate modifications to the bioventing cells and/or the biofilter systems. Some of the test instrumentation shown in Figure 8 will not be part of the full-scale treatability study design, but are included for the pilot test to evaluate piping sizes, flowrates, and pressure and vacuum distribution. Any proposed modifications to Figure 8 for the full-scale system will be presented in a letter report containing the pilot test results.

The following items will be addressed in this letter report:

- Soil and soil-gas sample analyses will be summarized. Any discovered correlation between field soil headspace results could be used to optimize the soil mixture within the bioventing cell so that volatile emissions are minimized.
- Respiration rates and biodegradation rates will be estimated from oxygen level changes measured during the respiration tests. These rates will be used to estimate the average remediation times needed for each cell. If measured respiration rates are slow during the pilot test, then the possibility of adding nutrients and/or additional moisture during the remainder of the treatability study will be addressed.
- Modification of the dimensions of the bioventing cells and biofilter will be presented as necessary to achieve optimum oxygen levels or proper blower sizing. Pipe diameters, slot sizes, and pipe configuration may also be modified.

5.2 Full-scale Treatability Study

Following approval by the Feather River Air Quality Management District (FRAQMD), up to eight additional bioventing cells will be installed as part of a full-scale treatability study. The configuration of these cells will be based on pilot test results. Moisture and nutrients will be added while the bioventing cells are laid out. Initial parameters including soil sampling (a minimum of one composite per 50 CY soil) and TPH and BTEX analysis using procedures similar to those used during the pilot test. Vacuum measurements at the end of the vent pipes protruding from the bioventing cells will be taken to insure that air is drawn from all piles. The temperature and soil moisture will be monitored periodically during bioventing.

Soil-gas samples will be collected using a soil-gas probe and analyzed using field instruments. Quarterly monitoring will also be performed at the VMPs in the pilot bioventing cell, and in the remaining bioventing cells to evaluate oxygen, carbon dioxide, and TPH levels in the soil gas. Oxygen levels are expected to be higher in the bioventing cells closer to the blower, compared to bioventing cells farther away from the blower. In this situation the blower feed rates and control valves would be set to maintain optimum oxygen levels at all of the piles. During the treatability study, oxygen levels will be measured only at the end of the pile furthest from where the vent pipe enters the soil.

Degradation rates in the bioventing cells will be verified during the full-scale treatability study by sampling the soil on a quarterly basis. If the cells are sized larger than during the pilot test~~, the same~~ ratio of samples to soil volume will be used (1:50). Soil headspace will be measured using the THVA. If these measurements indicate that TPH levels are below 100 ppm, soil samples will be analyzed by a laboratory using procedures identical to those used during the pilot test. The assessment of degradation rates will be based on the change of TPH compared to initial concentrations.

It is expected that the same biofilter will be used during the pilot test and throughout the treatability study. The configuration and volume of the biofilter will be modified if required. The ultimate objective of the treatability study is to configure a biofilter that will contain and treat potential emissions from the bioventing cells. A significant portion of the contaminated soil is from heating oil sources. Heating oil does not contain high levels of volatile components and BTEX was rarely detected during the tank removal

operations. Gasoline contaminated soil may have had a significant portion of the volatile fraction removed through natural biodegradation and volatilization gas over the last year. If little or no hydrocarbons are detected in the emissions from the bioventing cell, then additional tests to evaluate the biofilter performance will not be necessary.

The biofilter's ability to adsorb and biodegrade contaminants will be estimated based on soil-gas samples. Soils that can adsorb contaminants should contain significantly less contaminants near the surface of the soil compared to deep within the biofilter. Samples need to be collected early enough in the remediation process to assure that the soils are not saturated such as would happen with soils with a high adsorption capacity yet given enough time to develop a concentration differential within the biofilter. Soil-gas will continue to be monitored quarterly for oxygen, carbon dioxide and TVH.

how many & when

To characterize the biofilter performance, the gas entering and exiting the biofilter will be collected in Summa® canisters monthly and analyzed for TVH and BTEX. Soil samples will be collected from the biofilter at the second quarterly event. Waiting until the second quarterly event allows for evaluation of the biofilter after a significant quantity of volatiles have been introduced into the filter. Soil sampling procedures will be identical to those used during the pilot test.

REFERENCES

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Kampbell, Don, John Wilson, Harvey Read, Thomas Stocksdale 1987, Removal of Volatile Aliphatic Hydrocarbons in a Soil Bioreactor. Control Technology 37:10:1236-1240 p

APPENDIX A

TEST PLAN AND TECHNICAL PROTOCOL FOR A FIELD TREATABILITY TEST FOR BIOVENTING

TEST PLAN AND TECHNICAL PROTOCOL FOR A FIELD TREATABILITY TEST FOR BIOVENTING

To

U.S. Air Force

Center for Environmental Excellence

January 1992

Revision 1

TEST PLAN AND TECHNICAL PROTOCOL

FOR

A FIELD TREATABILITY TEST FOR BIOVENTING

by

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January 1992

TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

Page

LIST OF TABLES

LIST OF FIGURES

TABLE OF CONTENTS
(Continued)

TEST PLAN AND TECHNICAL PROTOCOL FOR A FIELD TREATABILITY TEST FOR BIOVENTING

1.0 TEST OBJECTIVES

This test plan and technical protocol describes the methods for conducting a field treatability test for the bioventing technology. The purpose of these field test methods is to measure the soil gas permeability and microbial activity at a contaminated site and to evaluate the potential application of the bioventing technology to remediate the contaminated site. The specific test objectives are stated below.

1.1 Conduct Air Permeability and In Situ Respiration Tests

At every site, the air permeability of the soil and the air vent (well) radius of influence will be determined. This will require air to be withdrawn or injected for approximately 8 hours at vent wells located in contaminated soils. Pressure changes will be monitored in an array of monitoring points. Immediately following this test, an in situ respiration test will be conducted. Air will be injected into selected monitoring points to aerate the soils. The in situ oxygen utilization and carbon dioxide production rates will be measured.

1.2 Conduct Bioventing Test

Using the data from the soil air permeability and in situ respiration tests, an air injection/withdrawal rate will be determined for use in the bioventing test. A blower will be selected, installed, and operated for 6 to 12 months, and periodic measurements of the soil gas composition will be made, to evaluate the long-term effectiveness of bioventing.

1.3 Use of Existing Wells and Monitoring Points

The U.S. Air Force has already installed monitoring points or other wells at many sites that will be suitable for use in this study. In keeping with the objective of developing a cost-effective program for site remediation, every effort will be made to use existing wells and minimize drilling costs.

2.0 INTRODUCTION TO BIOVENTING AND FIELD TREATABILITY TESTS

Bioventing is the process of aerating subsurface soils to stimulate in situ biological activity and promote bioremediation. Although it is related to the process of soil venting (aka soil vacuum extraction, soil gas extraction, and in situ soil stripping), their primary objectives are different. Soil venting is designed and operated to maximize the volatilization of low-molecular-weight compounds, with some biodegradation occurring. In contrast, bioventing is designed to maximize biodegradation of aerobically biodegradable compounds, regardless of their molecular weight, with some volatilization occurring. The major difference between these technologies is that the objective of soil venting is volatilization, and the objective of bioventing is biodegradation. Although both technologies involve venting of air through the subsurface, the differences in objectives result in different design and operation of the remedial systems.

2.1 Bioventing Background

Petroleum distillate hydrocarbons such as JP-4 jet fuel are generally biodegradable if the naturally occurring microorganisms that acclimate to the fuels as a carbon source are provided an adequate supply of oxygen and basic nutrients (Atlas, 1986). Natural biodegradation does occur, and at many sites microorganisms may eventually mineralize most of the fuel contamination. However, the process is dependent on natural oxygen diffusion rates (Ostendorf and Kambell, 1989). As a result, natural biodegradation is frequently too slow to prevent the spread of contamination and sites may require remediation to protect sensitive aquifers. Acceleration or enhancement of the natural biodegradation process may prove to be the most cost-effective remediation for hydrocarbon-contaminated sites.

Understanding the distribution of contaminants is important to any in situ remediation process. Much of the hydrocarbon residue at a fuel-contaminated site is found in the unsaturated zone soils, in the capillary fringe, and immediately below the water table. Seasonal water table fluctuations typically spread residues in the area immediately above and below the water table. Any successful bioremediation effort must treat these areas. Bioventing provides oxygen to unsaturated zone soils and can be extended below the water table when integrated with a dewatering system.

2.1.1 Conventional Enhanced Biodegradation

The practice of enhanced biodegradation for treating soluble fuel components in groundwater has increased over the past two decades (Lee et al., 1988), with less emphasis given to enhancing biodegradation in the unsaturated zone. Currently, conventional enhanced bioreclamation processes use water to carry oxygen or an alternative electron acceptor to the contaminated zone. This is common whether the contamination is present in the groundwater or in the unsaturated zone.

A recent field experiment at a jet fuel-contaminated site used infiltration galleries and spray irrigation to introduce oxygen (as hydrogen peroxide), nitrogen, and phosphorus to unsaturated, sandy soils. The experiment was unsuccessful because the rapid decomposition of hydrogen peroxide resulted in poor oxygen distribution (Hinchee et al., 1989).

Other attempts have been made using pure oxygen or hydrogen peroxide as oxygen sources, and recently nitrate has been added as an alternative to oxygen. Although results indicate better hydrogen peroxide stability than achieved by Hinchee et al. (1989), it was concluded that most of the hydrogen peroxide decomposed rapidly (Huling et al., 1990). Some degradation of aromatic hydrocarbons appears to have occurred; however, no change in total hydrocarbon contamination levels was detected in the soils (Ward, 1988).

In most cases where water is used as the oxygen carrier, the solubility of oxygen is the limiting factor for biodegradation. If pure oxygen is used and 40 mg/l of dissolved oxygen is achieved, approximately 80,000 lb of water must be delivered to the formation to degrade 1 lb of hydrocarbon. If 500 mg/l of hydrogen peroxide is successfully delivered, then approximately 13,000 lb of water must be used to degrade the same amount of hydrocarbon. As a result, even if hydrogen peroxide can be successfully used, substantial volumes of water must be pumped through the contaminated formation to deliver sufficient oxygen.

2.1.2 Bioventing

A system engineered to increase the microbial biodegradation of fuel hydrocarbons in the unsaturated zone using forced air as the oxygen source may be a cost-effective alternative to conventional systems. This process provides oxygen to indigenous soil microorganisms promoting aerobic metabolism of fuel hydrocarbons in unsaturated soils. Depending on airflow rates, some volatile compounds may be simultaneously stripped from contaminated soils.

When air is used as an oxygen source, 13 lb of air must be delivered to provide the minimum oxygen required to degrade 1 lb of hydrocarbon, compared to the more than 13,000 lb of water with 500 mg/l of hydrogen peroxide that must be delivered by conventional water phase-enhanced bioreclamation processes. An additional advantage of using a gas phase process is that gases have greater diffusivity than liquids. At many sites, geological heterogeneities cause fluid that is pumped through the formation to be channeled into the more permeable pathways (e.g., in an alluvial soil with interbedded sand and clay, all of the fluid flow initially takes place in the sand). As a result, oxygen must be delivered to the less permeable clay lenses through diffusion. In a gaseous system (as found in unsaturated soils), this diffusion can be expected to take place at rates several orders of magnitude greater than rates in a liquid system (as is found in saturated soils). Although it is not realistic to expect diffusion to aid significantly in water-based bioreclamation, diffusion of oxygen in a gas phase system may be a significant mechanism for oxygen delivery to less permeable zones.

To the authors' knowledge, the first documented evidence of unsaturated zone biodegradation resulting from forced aeration was reported by the Texas Research Institute, Inc., in a study for the American Petroleum Institute. A large-scale model experiment was conducted to test the effectiveness of a surfactant treatment to enhance the recovery of spilled gasoline. The experiment accounted for only 8 gal of the 65 gal originally spilled and raised questions about the fate of the gasoline. Subsequently, a column study was conducted to determine a diffusion coefficient for soil venting. This column study evolved into a biodegradation study in which it was concluded that as much as 38% of the fuel hydrocarbon was biologically mineralized. Researchers concluded that venting would not only remove gasoline by physical means, but also could enhance microbial activity and promote biodegradation of the gasoline (Texas Research Institute, 1980; 1984).

To the authors' knowledge, the first actual field-scale bioventing experiments were conducted by van Eyk for Shell Oil. In 1982 at van Eyk's direction, Delft Geotechnics in The Netherlands initiated a series of experiments to investigate the effectiveness of bioventing for treating hydrocarbon-contaminated soils. These studies are reported in a series of papers (Anonymous, 1986; Staatsuitgeverij, 1986; van Eyk and Vreeken, 1988, 1989a and 1989b).

Wilson and Ward (1986) suggested that using air as a carrier for oxygen could be 1,000 times more efficient than using water, especially in deep, hard-to-flood unsaturated zones. They made the connection between soil venting and biodegradation by observing that "soil venting uses the same principle to remove volatile components of the hydrocarbon." In a general overview of the soil venting process, Bennedsen et al. (1987) concluded that soil venting provides large quantities of oxygen to the unsaturated zone, possibly stimulating aerobic degradation. They suggested that water and nutrients would also be required for significant degradation and encouraged additional investigation into this area.

Biodegradation enhanced by soil venting has been observed at several field sites. Investigators claim that at a soil venting site for remediation of gasoline-contaminated soil significant biodegradation occurred (measured by a temperature rise) when air was supplied. Investigators pumped pulses of air through a pile of excavated soil and observed a consistent rise in temperature, which they attributed to biodegradation. They claimed that the pile was cleaned up during the summer primarily by biodegradation (Conner, 1988). However, they did not control for natural volatilization from the aboveground pile, and not enough data were published to critically review their biodegradation claim.

Researchers at Traverse City, Michigan, observed a decrease in the toluene concentration in unsaturated zone soil gas, which they measured as an indicator of fuel contamination in the unsaturated zone. They assumed that advection had not occurred and attributed the toluene loss to biodegradation. The investigators concluded that because toluene concentrations decayed near the oxygenated ground surface, soil venting is an attractive remediation alternative for biodegrading light volatile hydrocarbon spills (Ostendorf and Kambell, 1989).

The U.S. Air Force initiated its research and development (R&D) program in bioventing in 1988 with a study at Hill Air Force Base (AFB) in Utah. During this study it became apparent that bioventing had great potential for remediating JP-4 fuel-contaminated soils. It was also apparent that additional research would be needed before the technology could be routinely applied in the field. The work was initially supported by the U.S. Air Force Civil Engineering Support Agency (AFCESA), previously known as the Air Force Engineering and Services Center. Subsequently, they were joined in R&D support of the technology by the U.S. Air Force Center for Environmental Excellence (AFCEE) and later by Hill and Eielson AFBs. Following the Hill AFB study, a more controlled bioventing study was completed at Tyndall AFB in Florida.

The Air Force currently supports a number of field programs to further test and demonstrate the technology. After completion of the initial site testing at Hill AFB, a low-intensity bioreclamation research program at another site was initiated in late 1989. At Eielson AFB near Fairbanks, Alaska, a field demonstration of bioventing in a subarctic environment was initiated in the summer of 1991. This study includes a soil heating experiment to attempt to increase biodegradation rates.

The U.S. EPA Risk Reduction Engineering Laboratory (RREL) has become interested in the Air Force's program, and has jointly funded and technically supported the work at both Hill and Eielson AFBs. Additionally, the AFCESA is supporting a well-documented bioventing demonstration at a cold weather site with field work scheduled to begin in the summer of 1992.

2.1.3 Applications

The use of an air-based oxygen supply for enhancing biodegradation relies on airflow through hydrocarbon-contaminated soils at rates and configurations that will (1) ensure adequate oxygenation for aerobic biodegradation, and (2) minimize or eliminate the production of a hydrocarbon-contaminated off-gas. The addition of nutrients and moisture may be desirable to increase biodegradation rates; however, field research to date does not indicate the need for these additions (Dupont et al., 1991; Miller et al., 1991). If found necessary, nutrient and moisture addition could take any of a variety of configurations. Dewatering may at times be necessary, depending on the distribution of contaminants relative to the water table. A key feature of bioventing is the use of narrowly screened soil gas monitoring points to sample gas in short vertical sections of the soil. These points are required to monitor local oxygen concentrations, because oxygen levels in the vent well are not representative of local conditions.

A conventional soil venting system could be installed to draw air from a vent well in the area of greatest contamination. This configuration would allow straightforward monitoring of the off-gases. However, its disadvantage is that hydrocarbon off-gas concentration would probably be maximized, and could require permitting and treatment. Furthermore, all of the capillary fringe contamination may not be treated.

Figure 2-1 is a schematic representation of a bioventing system that involves air injection only. Although this is the lowest cost configuration, careful consideration must be given to the fate of injected air. The objective is for most, if not all, of the hydrocarbons to be degraded, and for CO_2 to be emitted at some distance from the injection point. If a building or subsurface structure were to exist within the radius of influence of the well, hydrocarbon vapors might be forced into that structure. Thus, protection of subsurface structures may be required.

Figure 2-2 is an illustration of a configuration in which air is injected (the injection may also be by passive well) into the contaminated zone and withdrawn from clean soils. This configuration allows the more volatile hydrocarbons to degrade prior to being withdrawn, thereby eliminating contaminated off-gases. This configuration typically does not require air emission permitting (site-specific exceptions may apply).

Figure 2-3 illustrates a configuration that may alleviate the threat to subsurface structures while achieving the same basic effect as air injection alone. In this configuration, soil gas is extracted near the structure of concern and reinjected at a safe distance. If necessary, makeup air can be added before injection.

Figure 2-4 illustrates a conventional soil venting configuration at sites where hydrocarbon emissions to the atmosphere are not a problem. This may be the preferred configuration. Dewatering, nutrient, and moisture additions are also illustrated. Dewatering will allow more effective treatment of deeper soils. The optimal configuration for any given site will, of course, depend on site-specific conditions and remedial objectives.

The significant features of this technology include the following:

- Optimizing airflow to reduce volatilization while maintaining aerobic conditions for biodegradation

- Monitoring local soil gas conditions to assure aerobic conditions, not just monitoring vent gas composition

- Adding moisture and nutrients as required to increase biodegradation rates although, as stated earlier, it appears from field studies that this may not be necessary at many if not most sites

- Manipulating the water table (dewatering) as required for air/contaminant contact.

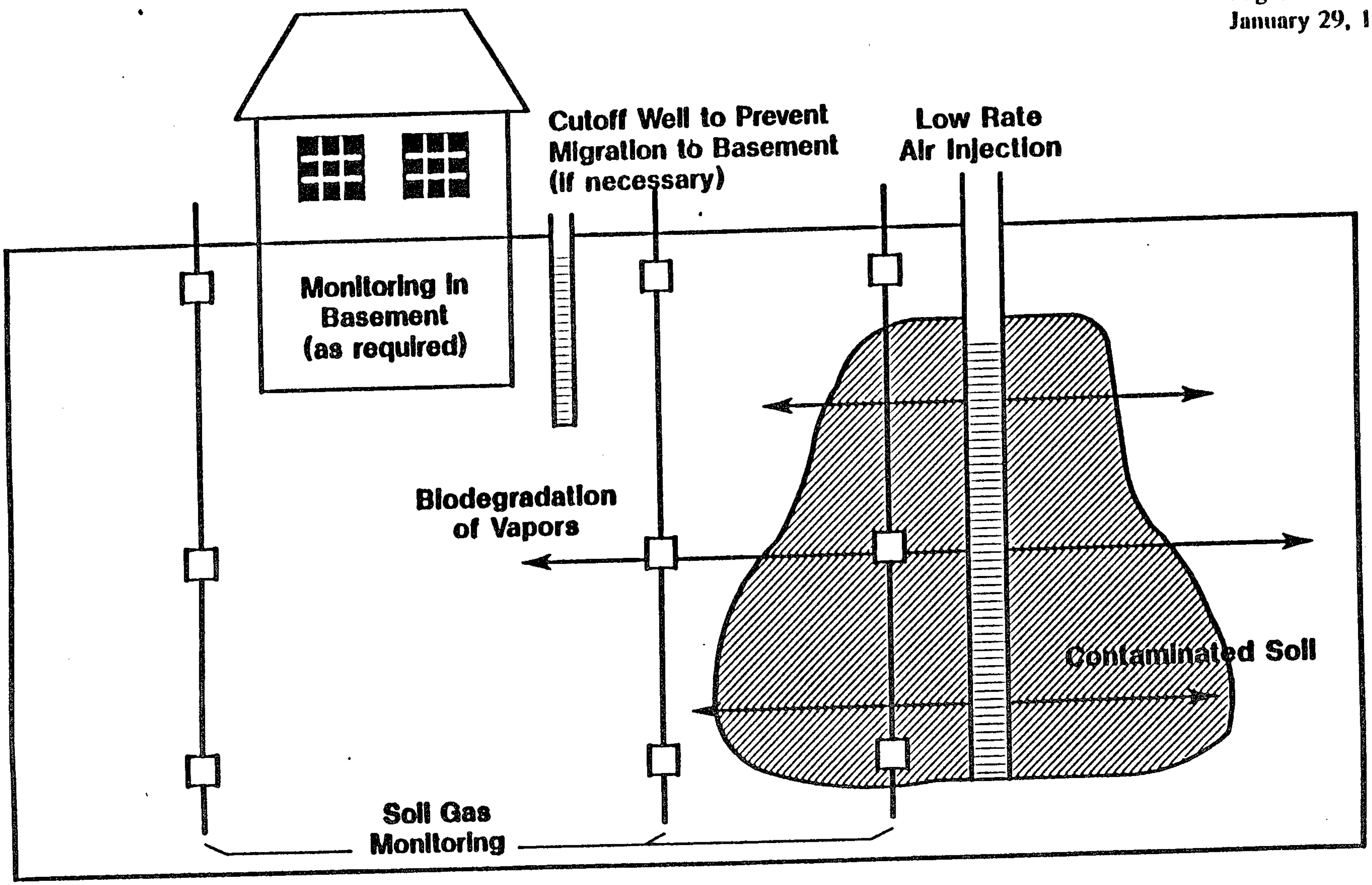

Figure 2-1. Conceptual Layout of Bioventing Process with Air Injection Only.

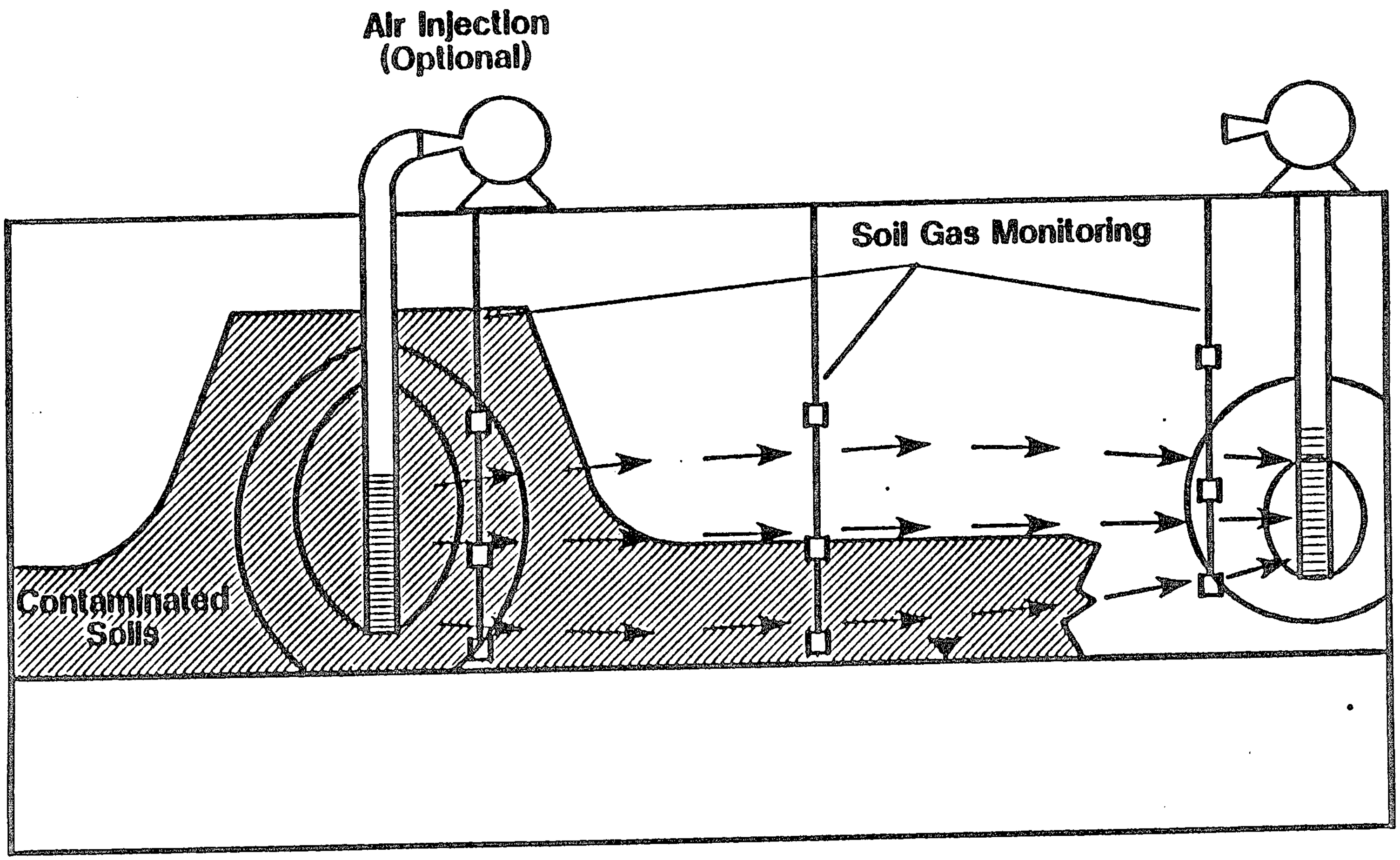

Figure 2-2. Conceptual Layout of Bioventing Process with Air Withdrawn from Clean Soil.

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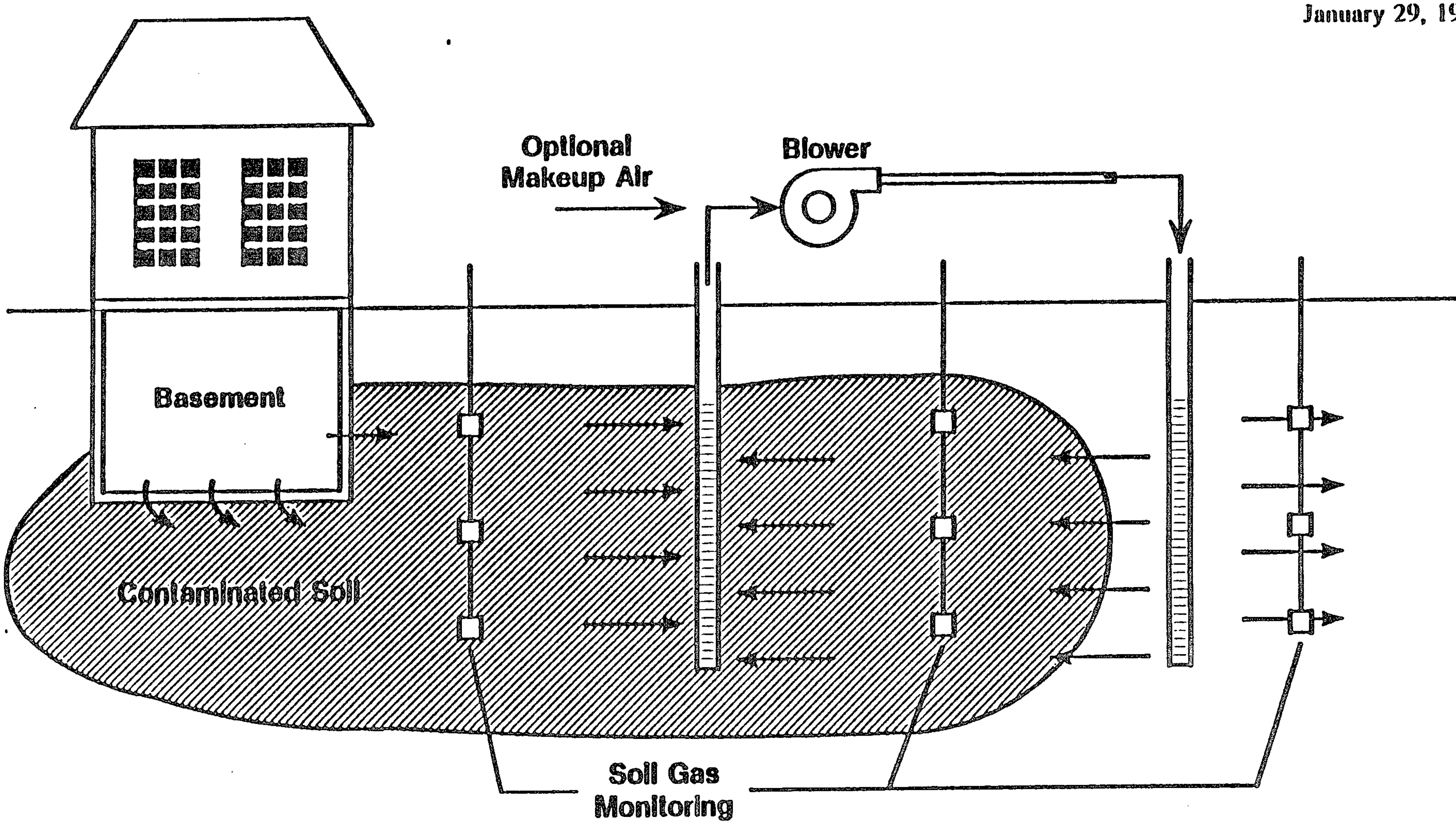

Figure 2-3. Conceptual Layout of Bioventing Process with Soil Gas Reinjection.

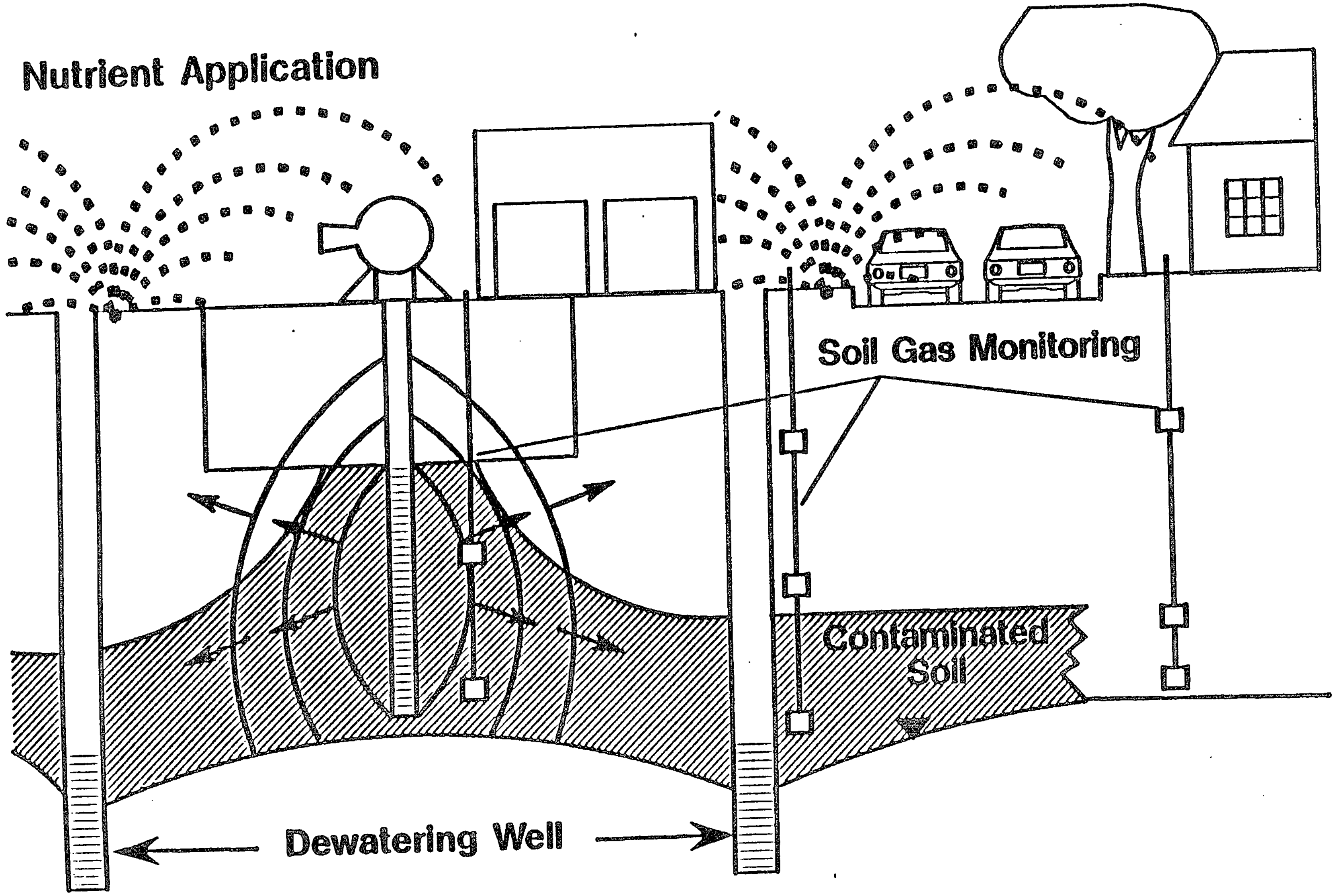

Figure 2-4. Conceptual Layout of Bioventing Process with Air Injection into Contaminated Soil, Coupled with Dewatering and Nutrient Application.

2.1.4 Hill AFB Site

A spill of approximately 26,420 gal of JP-4 jet fuel occurred when an automatic overflow device failed at Hill AFB in Ogden, Utah. The contamination was found primarily in the upper 66 ft of a delta outwash of the Weber River. This surficial formation extends from the surface to a depth of approximately 66 ft and is composed of mixed sand and gravel with occasional clay stringers. Depth to regional groundwater is approximately 660 ft; however, water may occasionally be found in discontinuous perched zones. Soil moisture averaged less than 6% in the contaminated soils.

The collected soil samples had JP-4 fuel concentrations up to 20,000 mg/kg, with an average concentration of approximately 400 mg/kg (Oak Ridge National Laboratory, 1989). Contaminants were unevenly distributed to depths of 66 ft. Vent wells were drilled to approximately 66 ft below the ground surface and were screened from 10 to 60 ft below the surface. A background vent was installed in an uncontaminated location in the same geological formation approximately 660 ft north of the site.

Venting was initiated in December 1988 by air extraction at a rate of $\sim$1,600 ft^3/hr (cfh). The off-gas was treated by catalytic incineration, and it was initially necessary to dilute the highly concentrated gas to remain below explosive limits and within the incinerator's hydrocarbon operating limits. The venting rate was gradually increased to $\sim$88,000 cfh as hydrocarbon concentration levels dropped. During the period between December 1988 and November 1990, more than 3.53×10^8 ft^3 of soil gas were extracted from the site. In November 1989, ventilation rates were reduced to between $\sim$17,600 and 35,000 cfh to provide aeration for bioremediation while reducing off-gas volatility. This change allowed removal of the catalytic incinerator, saving $\sim$\$6,000 per month.

During extraction, oxygen and hydrocarbon concentrations in the off-gas were measured. To quantify the extent of biodegradation at the site, the oxygen was converted to an equivalent basis. This was based on the stoichiometric oxygen requirement for hexane mineralization. JP-4 hydrocarbon concentrations were determined based on direct readings of a total hydrocarbon analyzer calibrated to hexane. Based on these calculations, the mass of the JP-4 fuel as carbon removed was $\sim$116,840 lb volatilized and 92,590 lb biodegraded. Figures 2-5 and 2-6 illustrate these results.

Hinchee and Arthur (1991) conducted bench-scale studies using soils from this site and found that, in the laboratory, both moisture and nutrients became limiting after aerobic conditions were achieved. This led to the addition of first moisture and then nutrients in the field. The results of these field additions are shown in Figure 2-5. Moisture addition clearly stimulated biodegradation; nutrient addition did not.

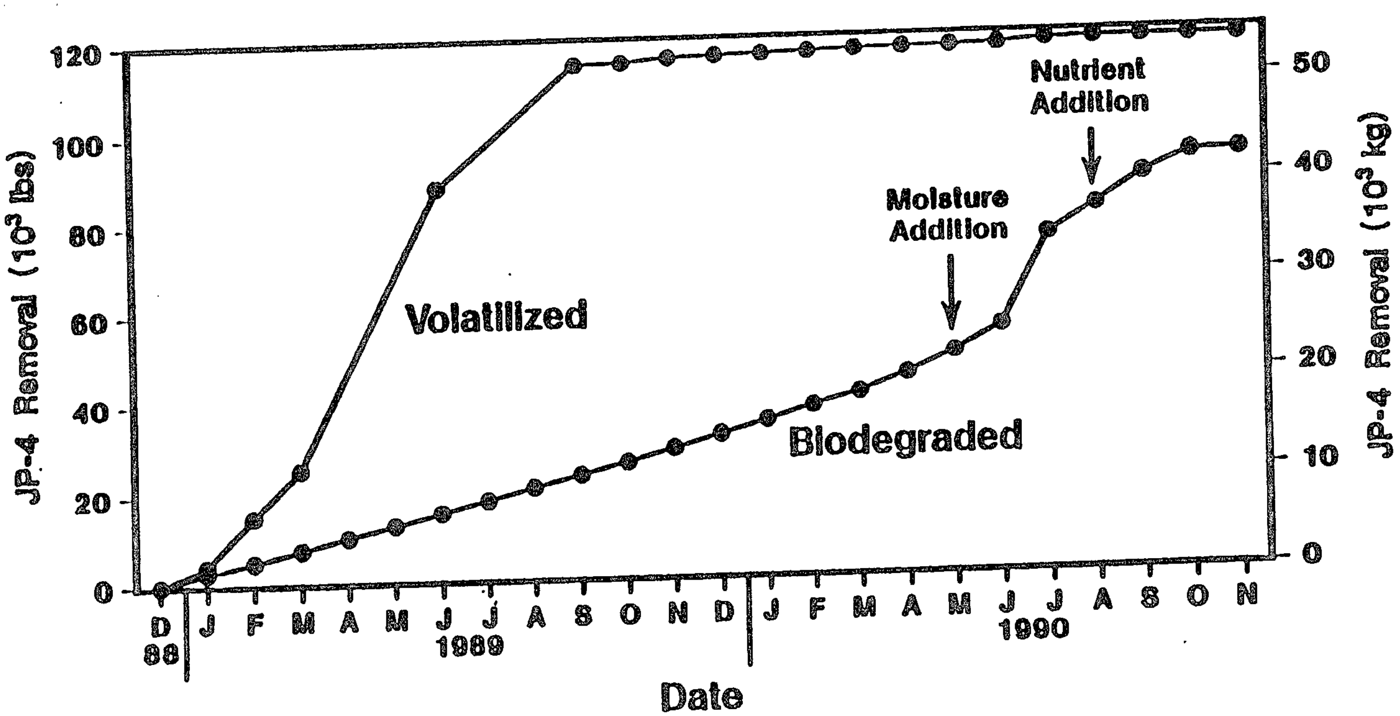

Figure 2-5. Cumulative Hydrocarbon Removal from the Hill AFB Building 914 Soil Venting Site.

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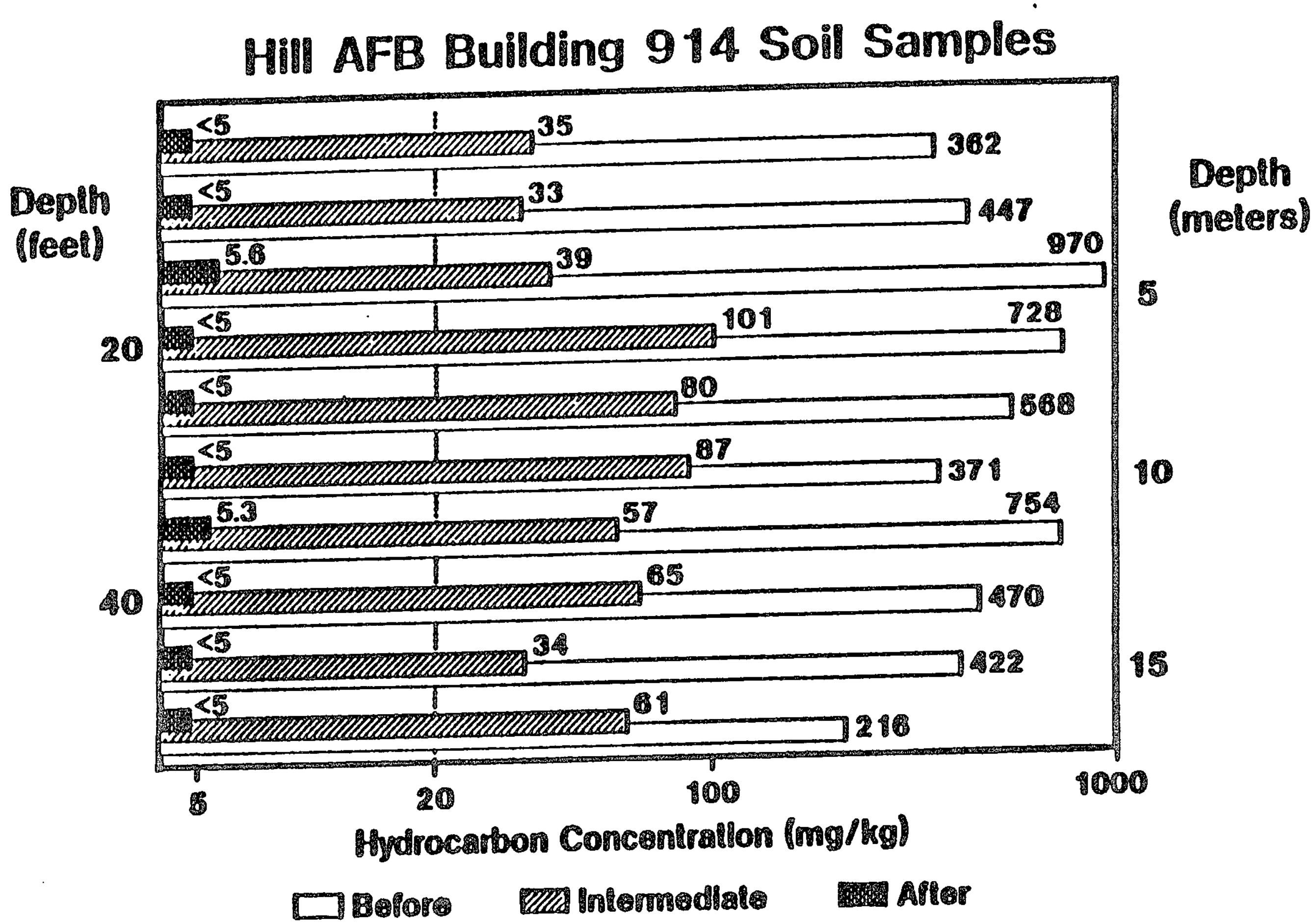

Figure 2-6. Results of Soil Analysis at Hill AFB Before and After Venting. (Each bar represents the average of 14 or more samples.)

The failure to observe an effect of nutrient addition could be explained by a number of factors, including:

- The nutrients failed to move in the soils; this is a problem particularly for ammonia and phosphorus (see Aggarwal et al., 1991).
- Remediation of the site was entering its final phase, and the nutrient addition may have been too late to result in an observed change.
- Nutrients simply may have not been limiting.

2.1.5 Tyndall AFB Site

As a follow-up to the Hill AFB research, a more controlled study was designed at Tyndall AFB. The experimental area in this study was located at a site where past JP-4 fuel storage had resulted in contaminated soils. The nature and volume of fuel spilled or leaked were unknown. The site soils are a fine- to medium-grained quartz sand. The depth to groundwater is 1.6 to 3.3 ft.

Four test cells were constructed to allow control of gas flow, water flow, and nutrient addition. Test cells V1 and V2 were installed in the hydrocarbon-contaminated zone; the other two were installed in uncontaminated soils. Initial site characterization indicated the mean soil hydrocarbon levels were 5,100 and 7,700 mg of hexane-equivalent/kg in treatment plots V1 and V2, respectively. The contaminated area was dewatered, and hydraulic control was maintained to keep the depth to water at ~5.25 ft. This exposed more of the contaminated soil to aeration. During normal operation, airflow rates were maintained at approximately one air-filled void volume per day.

Biodegradation and volatilization rates were much higher at the Tyndall AFB site than those observed at Hill AFB; these higher rates were likely due to higher average levels of contamination, warmer temperatures, and the presence of moisture. After 200 days of aeration, an average hydrocarbon reduction of ~2,900 mg/kg was observed. This represents a reduction in total hydrocarbons of approximately 40%.

The study was terminated because the process monitoring objectives had been met; biodegradation was still vigorous. Although the total petroleum hydrocarbons had been reduced by only 40%, the low-molecular-weight aromatics — benzene, toluene, ethylbenzene, and xylenes (BTEX) — were reduced by more than 90% (see Figure 2-7). It appears that the bioventing process more rapidly removes the BTEX compounds than the other JP-4 fuel constituents.

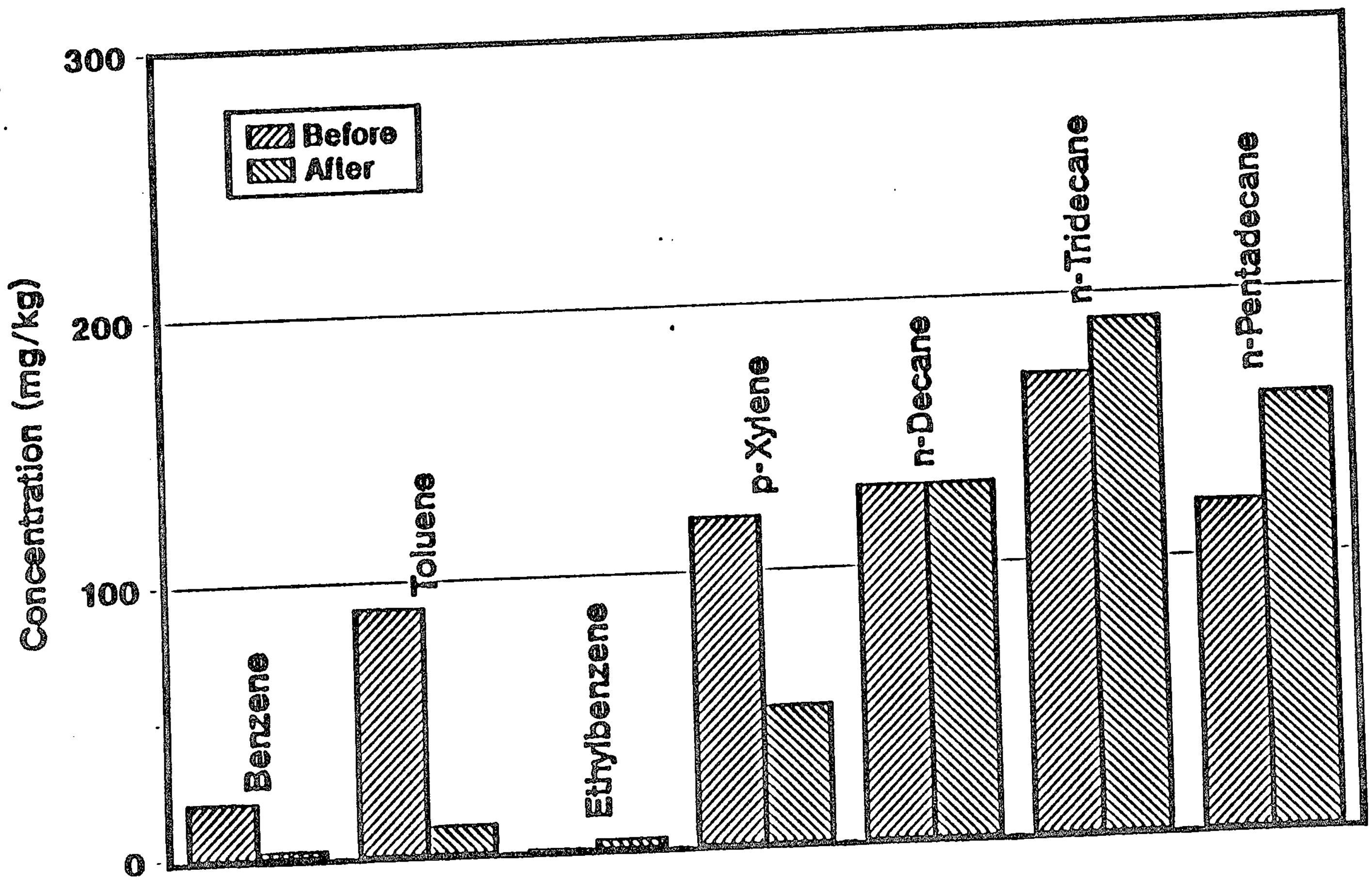

Figure 2-7. Results of Soil Analysis from Plot V2 at Tyndall AFB Before and After Venting. Each bar represents the average of 21 or more soil samples.

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Another important observation of this study is the effect of temperature on the biodegradation rate. Miller (1990) found that the van Hoff-Arrhenius equation provided an excellent model of temperature effects. In the Tyndall AFB study, soil temperature varied by only ~7°C, yet biodegradation rates were approximately twice as high at 25°C than at 18°C.

In the Tyndall AFB study, the effects of moisture and nutrients were observed in a field test. Two side-by-side plots received identical treatment, except that one (V2) received both moisture and nutrients from the outset of the study while the other plot (V1) received neither for 8 weeks, then moisture only for 14 weeks, followed by both moisture and nutrients for 7 weeks. As illustrated in Figure 2-8, no significant effect of moisture or nutrients was observed. The lack of moisture effect contrasts with the Hill AFB findings, but is most likely the result of contrasting climatic and hydrogeologic conditions. Hill AFB is located on a high-elevation desert with a very deep water table. Tyndall AFB is located in a moist subtropical environment, and at the site studied, the water table was maintained at a depth of less than 5.25 ft.

The nutrient findings support field observations at Hill AFB that the addition of nutrients does not stimulate biodegradation. Based on acetylene reduction studies, Miller (1990) speculates that adequate nitrogen was present due to nitrogen fixation. Both the Hill and Tyndall AFB sites were contaminated for several years before the bioventing studies, and both sites were anaerobic. It is possible that nitrogen fixation, which is maximized under these conditions, provided the required nutrients. In any case, these findings show that nutrient addition is not always required.

2.2 Soil Gas Permeability and Radius of Influence

An estimate of the soil's permeability to fluid flow (k) and the radius of influence (R_I) of venting wells are both important elements of a full-scale bioventing design. On-site testing provides the most accurate estimate of the soil gas permeability, k. On-site testing can also be used to determine the radius of influence that can be achieved for a given well configuration and its flow rate and air pressure. These data are used to design full-scale systems, specifically to space venting wells, to size blower equipment, and to ensure that the entire site receives a supply of oxygen-rich air to sustain in situ biodegradation.

Soil gas permeability, or intrinsic permeability, can be defined as a soil's capacity for fluid flow, and varies according to grain size, soil uniformity, porosity, and moisture content. The value of k is a physical property of the soil; k does not change with different extraction/injection rates or different pressure levels. Soil gas permeability is generally expressed in the units cm^2 or darcy (1 darcy = 1×10^{-8} cm^2). Like hydraulic conductivity, soil gas permeability may vary by more than an order of magnitude on the same site due to soil variability. Table 2-1 illustrates the range of typical k values to be expected with different soil types.

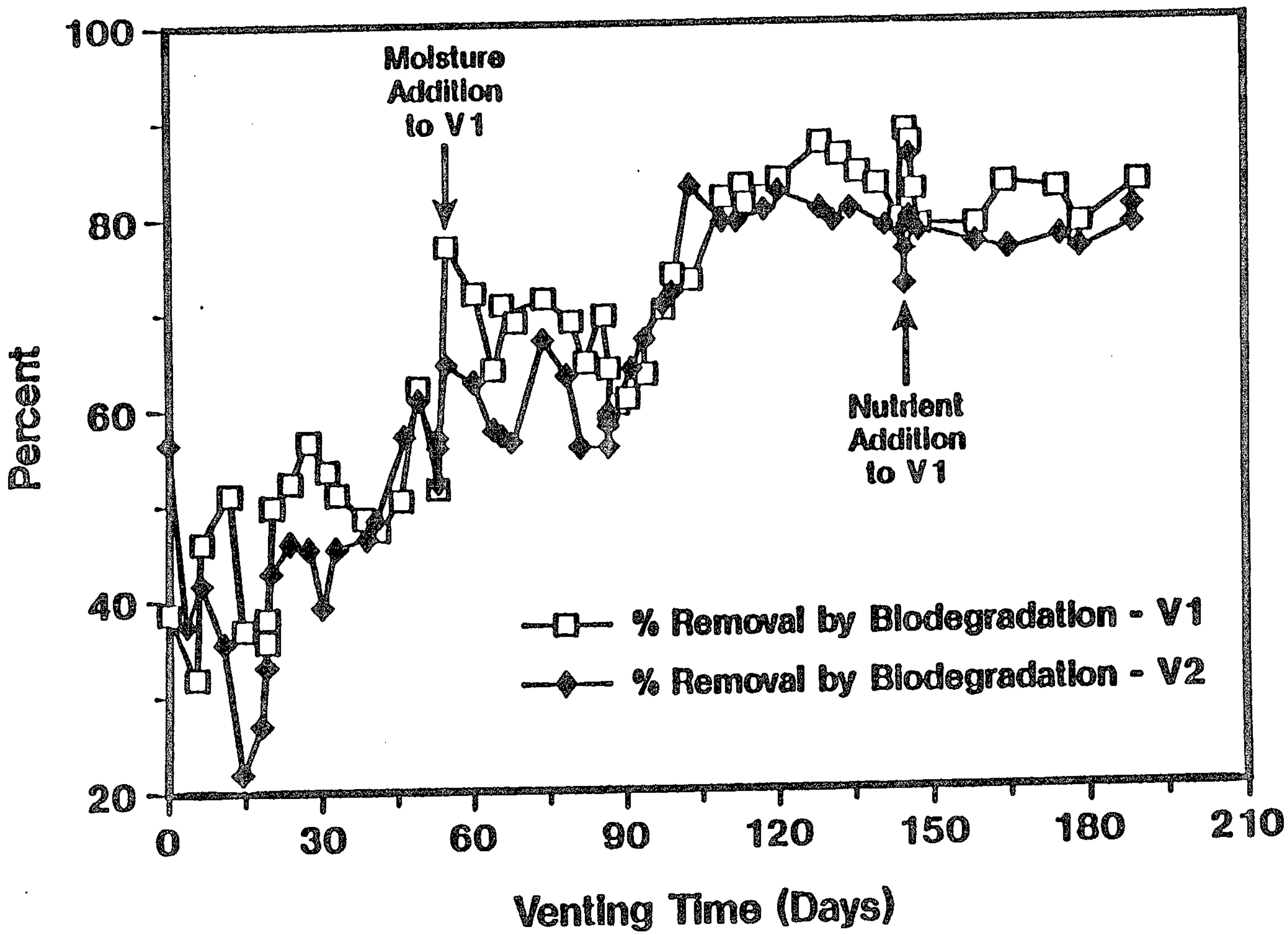

Figure 2-8. Cumulative Percent Hydrocarbon Removal at Tyndall AFB for Sites V1 and V2.

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TABLE 2-1. Soil Gas Permeability Values

Soil Type	k in Darcy
Coarse Sand	100-1000
Medium Sand	1-100
Fine Sand	0.1-1.0
Silts/Clays	<0.1

Source: Johnson et al. (1990)

The radius of influence is defined as the maximum distance from the air extraction or injection well where measurable vacuum or pressure (soil gas movement) occurs. R_I is a function of soil properties, but is also dependent on the configuration of the venting well and extraction or injection flow rates, and is altered by soil stratification. On sites with shallow contamination, the radius of influence can also be increased by impermeable surface barriers such as asphalt or concrete. These paved surfaces may or may not act as vapor barriers. Without a tight seal to the native soil surface, the pavement will not significantly impact soil gas flow.

Several field methods have been developed for determining soil gas permeability (see review by Sellers and Fan, 1991). The most favored field test method is probably the modified field drawdown method developed by Paul Johnson and associates at the Shell Development Company. This method involves the injection or extraction of air at a constant rate from a single venting well while measuring the pressure/vacuum changes over time at several monitoring points in the soil away from the venting well. A detailed description of the method, including equations to compute k, is presented in the Appendix.

2.3 In Situ Respiration Testing

As part of the Air Force's bioventing R&D program, a test was identified to provide rapid field measurement of in situ biodegradation rates so that a full-scale bioventing system can be designed. This section describes such a test as developed by Hinchee et al. (1991b). This respiration test has been used at numerous sites throughout the United States. The in situ respiration test described in this protocol (Sections 4.0 and 5.0) is essentially the same with minor modifications.

The in situ respiration test consists of placing narrowly screened soil gas monitoring points into the unsaturated zone fuel-contaminated and uncontaminated soils and

venting these soils with air containing an inert tracer gas for a given period of time. The apparatus for the respiration test is illustrated in Figure 2-9. In a typical experiment, two monitoring point locations — the test location and a background control location — were used. A cluster of three to four probes were usually placed in the contaminated soil of the test location. A 1 to 3% concentration of inert gas was added to the air, which was injected for about 24 hours. The air provided oxygen to the soil, while inert gas measurements provided data on the diffusion of O_2 from the ground surface and the surrounding soil and assured that the soil gas sampling system did not leak. The background control location was placed in an uncontaminated site with air injection to monitor natural background respiration.

Measurements of CO_2 and O_2 concentrations in the soil gas were taken before any air and inert gas injection. After air and inert gas injection were turned off, CO_2 and O_2 and inert gas concentrations were monitored over time. Before a reading was taken, the probe was purged for a few minutes until the CO_2 and O_2 readings were constant. Initial readings were taken every 2 hours and then progressively over 4- to 8-hour intervals. The experiment was usually terminated when the O_2 concentration of the soil gas was ~5%.

The monitoring points in contaminated soil at each site showed a significant decline in O_2 over a 40- to 80-hour monitoring period. Figure 2-10 illustrates the average results from four sites, along with the corresponding O_2 utilization rates in terms of percent of O_2 consumed per hour. In general, little or no O_2 utilization was measured in the uncontaminated background well. Inorganic uptake of O_2 was assumed to be negligible, as seen by the low available iron present in the soil. Aerating the soil for 24 hours was assumed to be sufficient to oxidize any ferrous ions. Table 2-2 provides a summary of in situ respiration rates and reported bioventing data.

The biodegradation rates measured by the in situ respiration test appear to be representative of those for a full-scale bioventing system. Miller (1990) conducted a 9-month bioventing pilot project at Tyndall AFB at the same time Hinchee et al. (1991b) were conducting their in situ respiration test. The O_2 utilization rates (Miller, 1990) measured from nearby active treatment areas were virtually identical to those measured in the in situ respiration test.

CO_2 production proved to be a less useful measure of biodegradation than O_2 disappearance. The biodegradation rate in milligrams of hexane-equivalent/kilograms of soil per day based on CO_2 appearance is usually less than can be accounted for by the O_2 disappearance. The Tyndall AFB site was an exception. That site had low-alkalinity soils and low-pH quartz sands, and CO_2 production actually resulted in a slightly higher estimate of biodegradation (Miller, 1990). In the case of the higher pH and higher alkalinity soils at Fallon NAS and Eielson AFB, little or no gaseous CO_2 production was measured (Hinchee et al., 1991b). This could be due to the formation of carbonates from the gaseous evolution of CO_2 produced by biodegradation at these sites. A similar problem was encountered by van Eyk and Vreeken (1988) in their attempt to use CO_2 evolution to quantify biodegradation associated with soil venting.

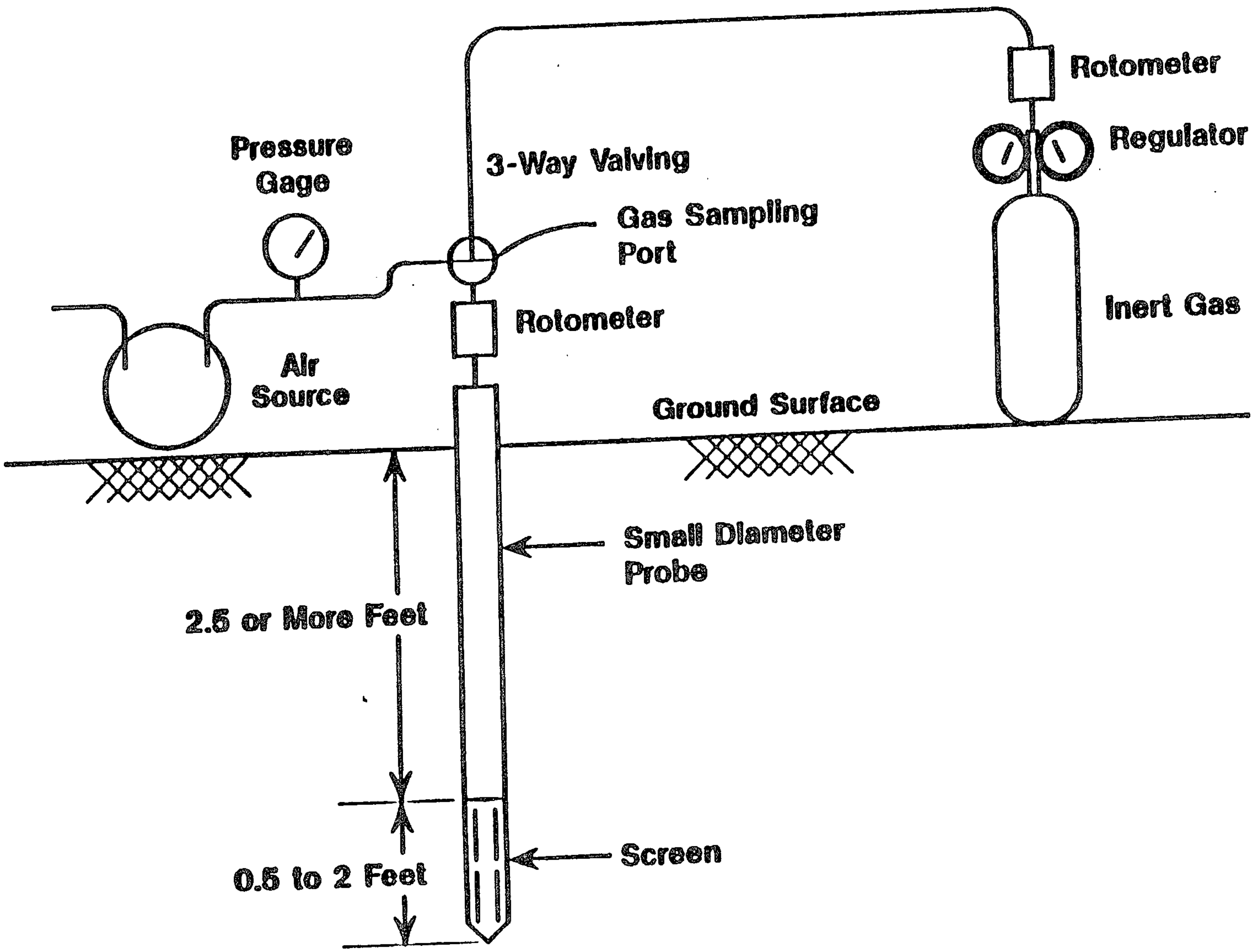

Figure 2-9. Gas Injection/Soil Gas Sampling Monitoring Point Used by Hinchee et al. (1991) in Their In Situ Respiration Studies.

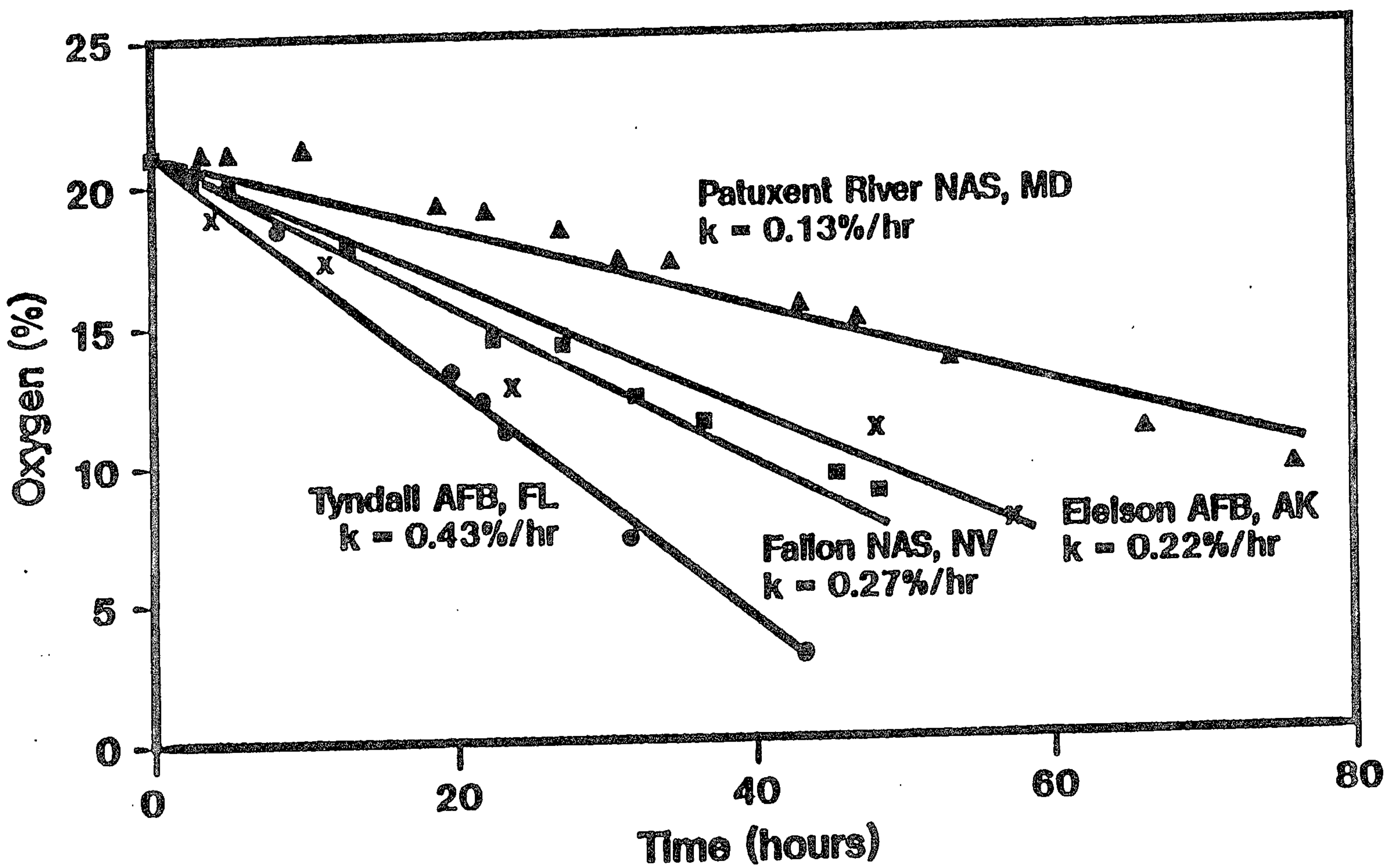

Figure 2-10. Average Oxygen Utilization Rates Measured at Four Test Sites.

TABLE 2-2. Summary of Reported In Situ Respiration and Bioventing Rate Data

Site	Scale of Application	Contaminant	In Situ Respiration Rates (% O_2/hr)	Estimated Biodegradation Rates	Reference
Hill AFB, Utah	Full-scale, 2 years	JP-4 jet fuel	up to 0.52	Up to 10 mg/(kg day)[a,b]	Hinchee et al., 1991a
Tyndall AFB, Florida	Field pilot, 1 year and in situ respiration test	JP-4 jet fuel	0.1 - 1.0	2-20 mg/(kg day)	Miller, 1990 and Hinchee et al., 1991b
The Netherlands	Undefined	Undefined	0.1 - 0.26	2-5 mg/(kg day)[b]	Urlings et al., 1990
The Netherlands	Field pilot, 1 year	Diesel	0.42	8 mg/(kg day)	van Eyk and Vreeken, 1989b
Undefined	Full scale	Gasoline and diesel	—	50 kg/(well day)[c]	Ely and Heffner, 1988
Undefined	Full scale	Diesel	—	100 kg/(well day)[c]	Ely and Heffner, 1988
Undefined	Full scale	Fuel oil	—	60 kg/(well day)[c]	Ely and Heffner, 1988
Patuxent River NAS, Maryland	In situ respiration test	JP-5 jet fuel	0.16	3 mg/(kg day)	Hinchee et al., 1991b
Fallon NAS, Nevada	In situ respiration test	JP-5 jet fuel	0.26	5 mg/(kg day)	Hinchee et al., 1991b
Eielson AFB, Alaska	In situ respiration test	JP-4 jet fuel	0.05 - 0.5	1-10 mg/(kg day)	Hinchee et al., 1991b
Kenai, Alaska	In situ respiration test	Crude Petroleum	1.1	21 mg/(kg day)	Hinchee and Ong, 1991
Tinker AFB, Oklahoma	In situ respiration test	JP-4 and mixed fuels	0.14 - 0.94	2.7 - 18 mg/(kg day)	Hinchee and Smith, 1991

[a] Rates reported by Hinchee et al., (1991) were first order with respect to oxygen; for comparative purposes, these have been converted to zero order with respect to hydrocarbons at an assumed oxygen concentration of 10%.

[b] Rates were reported as oxygen consumption rates; these have been converted to hydrocarbon degradation rates assuming a 3:1 oxygen-to-hydrocarbon ratio.

[c] Units are in kilograms of hydrocarbon degraded per 30 standard cubic feet per minute (scfm) extraction vent well per day.

3.0 IN SITU RESPIRATION/AIR PERMEABILITY TEST PREPARATION

The necessary preparation, procedures, and specific tasks to conduct the in situ respiration/air permeability test are presented in the following subsections. Figure 3-1 shows a generalized flow chart of the process.

3.1 Site Characterization Review

To initiate site characterization, the project officer will inform the contractor of the Air Force facilities and specific sites where these tests will be conducted. The project officer will also provide a contact person at each Air Force facility (hereafter called base point-of-contact, or base POC). The project officer and/or the base POC will supply any relevant documents (site characterization reports, remedial investigation/feasibility studies, etc.) pertaining to the contaminated area.

A tentative test site will be selected after reviewing all preliminary documents and consulting with the project officer and the base POC. Final approval of the test area will be obtained from the project officer.

3.2 Development of Site-Specific Test Plan

All involved parties for a given site will be provided with a site-specific test plan. The site-specific test plan will consist of this generic test plan with a site-specific cover letter. The following information will typically be provided in the cover letter:

- A map showing the chosen test location, and if possible, tentative vent well and monitoring point locations
- Construction details for tentative vent well and monitoring points
- Details of any required permits and actions taken to obtain the permits
- Estimated field start date
- Any anticipated deviations from the generic test plan
- Site-specific support required from the base
- Site-specific health and safety requirements, if required.

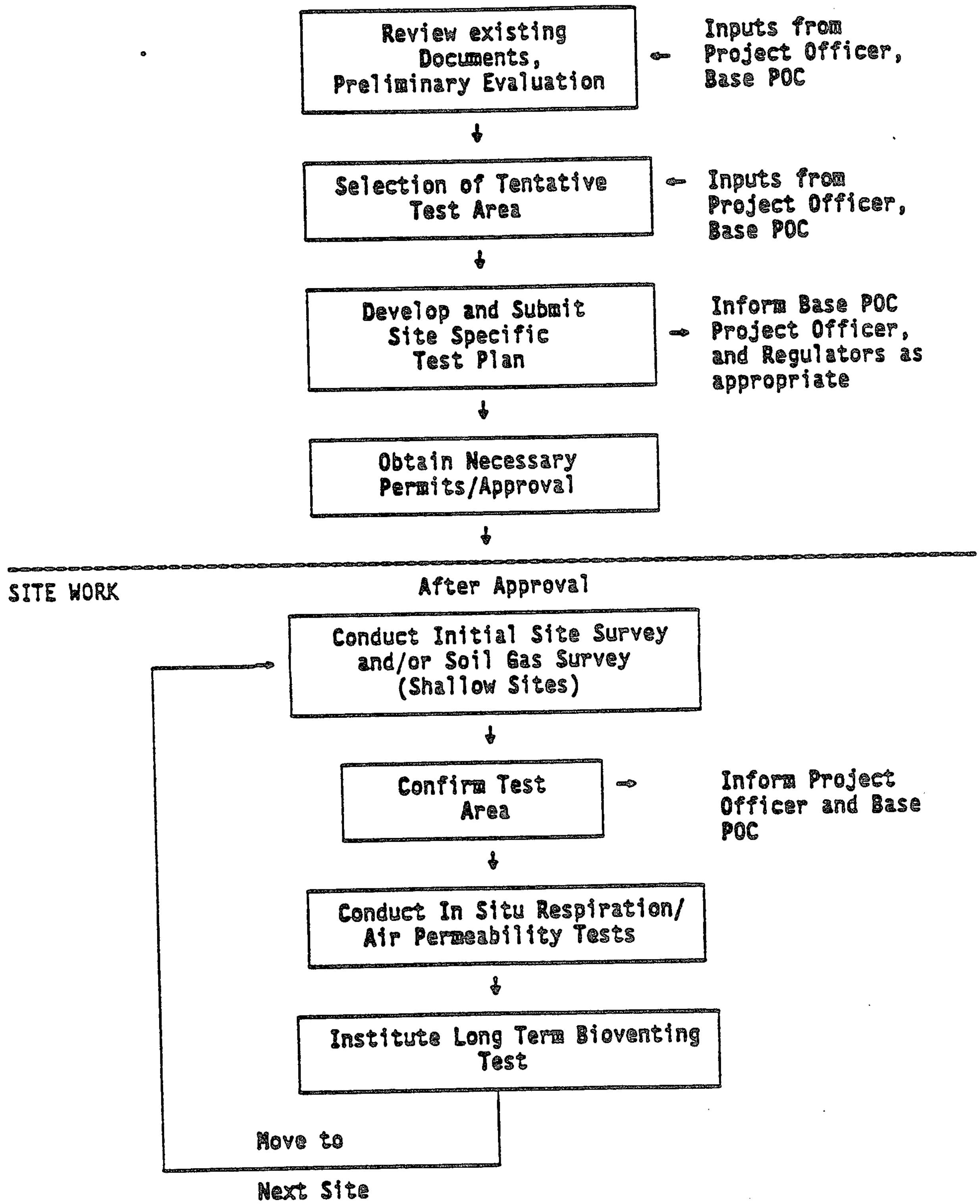

Figure 3-1. Flow Chart for Conducting Bioventing Treatability Test.

The site-specific test plan will be submitted to the project officer, base POC, and any necessary regulatory agencies for approval. The test plan will normally be submitted to outside regulatory agencies by either the project officer or the base POC. Unless specifically directed otherwise by the project officer, the contractor will not directly contact regulatory agencies or submit plans to them. No site work will be initiated without the necessary approval.

3.3 Application for Required Permits

As soon as a candidate site is identified by the Air Force project officer, applications must be submitted for the required permits. Obtaining permits frequently is the greatest holdup in accomplishing this type of field work. It is likely that no state or local permits will be required, but this must be determined early. Types of permits that may be required include:

- Drilling and/or well installation permits for the vent well and/or monitoring points
- Air Emission Permit for the vent well if air is extracted.
- Site Investigation Permit or Approval. In some California jurisdictions (and likely elsewhere), regulatory agencies require that all investigations at contaminated sites receive prior approval. This test should not normally be considered a CERCLA treatability test.

No direct contact will be made by the contractor with regulatory agencies without project officer and base POC approval. In many cases the project officer or base POC will handle regulatory contacts, if they are necessary.

The contractor will coordinate with the base POC to obtain access and necessary clearance to conduct the tests at the candidate test area. The contractor will arrange with the base for the utilities — electricity and water — needed to execute the tests. If electricity is not available, the contractor will provide power from portable generators. The contractor will coordinate with the base POC to obtain any necessary security clearances or badges.

As early as possible, the contractor will supply the base POC with a list of all personnel to be used on base, including name, social security number, place and date of birth, and expected arrival date. The contractor will also request that the base POC initiate the process of obtaining a digging permit.

4.0 TEST WELLS AND EQUIPMENT

This section describes the test wells and equipment that are required to conduct the field treatability tests. It must be recognized that site-specific flexibility will be required, and thus, details will vary. Local and/or state regulatory agencies and at times individual Air Force bases will have specific requirements that differ from specifications in this test plan. All testing must comply with regulations, and must be acceptable to the host base.

Field notes will be maintained describing all vent well and monitoring point construction. Deviations from standard design will be noted in the final report.

4.1 Vent Wells

A vent well and blower system will be established to provide airflow through the subsurface, creating a pressure/vacuum gradient for air permeability testing and increasing subsurface oxygen levels for in situ respiration testing. This 2- to 4-in. vent well will be placed with the screened section in contaminated soil and will be located near the center of the fuel spill. The siting and construction of the venting well will follow these general criteria:

1. The vent well will be sited as near to the center of the spill area as possible. This location will ensure that data gathered from the test will be as representative as possible of contaminated soil conditions. On many small sites, the vent well used during the treatability test can be converted into the primary vent well for extended testing.

2. The diameter of the vent well may vary between 2 and 4 in. and will depend on the ease of drilling and the area and depth of the contaminated volume. On most sites a 2-in.-diameter vent will provide adequate airflow for air permeability/radius of influence testing. For sites with contamination extending below 30 ft, a 3- or 4-in. vent well is recommended. The cost of a larger well is a minor component of the total drilling cost because a drill rig will be required to drill to this depth, regardless of well diameter. Groundwater monitoring points screened several ft above the existing water table can also be converted to vent wells. This option is appropriate for air injection systems but will be less successful for air extraction systems because the applied vacuum will cause a rise in the water table which could rapidly submerge the screened interval.

3. The vent well will normally be constructed of schedule 40 polyvinyl chloride (PVC), and will be screened with a slot size that maximizes airflow through the soil. The screened interval will extend through as much of the contaminated profile as possible, with the bottom of the screen corresponding to the top of the capillary fringe. For shallow sites with groundwater less than 20 ft deep, the vent well will be screened over the bottom half of the unsaturated zone. For deeper wells, care must be taken in determining the depth of the top of the screen. A deeper screen is normally better. If the top of the screen is close to the ground surface, much of the airflow may follow the shortest path from near the top of the screen to the ground surface.

4. Hollow-stem augering is the recommended drilling method; however, a solid-stem auger is also acceptable in more cohesive soils. Whenever possible, the diameter of the annular space will be at least two times greater than the vent well outside diameter. The annular space corresponding to the screened interval will be filled with silica sand or equivalent. In shallow softer soils, hand-augering may be feasible. The annular space above the screened interval will be sealed with wet bentonite and grout to prevent short-circuiting of air to or from the surface. Figure 4-1 shows a typical vent well.

4.2 Soil Gas Monitoring Points

Soil gas monitoring points will be used for pressure and soil gas measurements and will be installed at a minimum of three locations, and at each location to at least three depths. The total number will vary, with up to six monitoring point locations, and six or more depths, depending on site conditions.

To the extent possible, the monitoring points will be located in contaminated soils with >1,000 mg/kg of total petroleum hydrocarbon. These soils will have a strong odor and will feel oily to the touch. It may not be possible to locate all monitoring points in contaminated soil, especially the points furthest from the vent well. If this is the case, it is important to ensure that the point closest to the vent well be located in contaminated soil, and if possible, the intermediate point be placed in contaminated soils. If no monitoring points are located in contaminated soil, no meaningful in situ respiration test can be conducted. If the initial oxygen levels in the soil gas are not low, i.e., below 2 to 5%, and the hydrocarbon levels are not high, say above 10,000 ppm for relatively fresh JP-4 fuel, the monitoring point may not be suitable for an in situ respiration test.

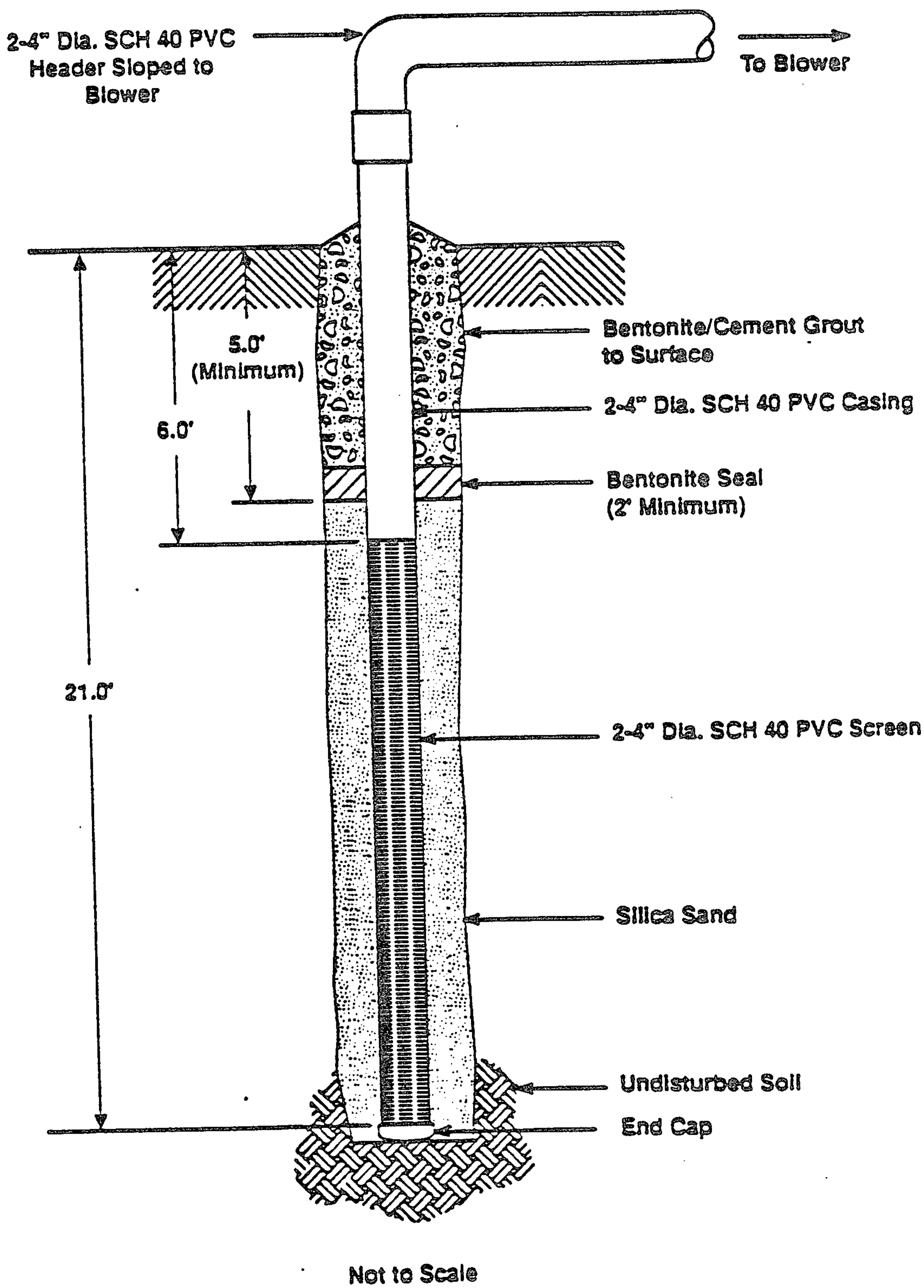

Figure 4-1. Typical Injection/Vacuum Venting Well Construction.

Higher oxygen concentrations would indicate that the microbial activity is not oxygen-limited or that there is sufficient exchange of air with the atmosphere to keep the soil gas well-aerated. In either case, bioventing will not increase biodegradation rates. At some sites, where less contaminated soils and low O_2 concentrations are encountered, bioventing may still be feasible. If these conditions are found, care must be taken to place the monitoring points in the most contaminated soil possible.

4.2.1 Location of Monitoring Points

A minimum of 3 monitoring points is recommended; ideally these will be in a straight line and at the intervals recommended in Table 4-1. In an unobstructed heterogeneous site, 3 monitoring points at these spacings are appropriate. Additional monitoring point locations may be necessary for a variety of site-specific reasons including, but not limited to, spatial heterogeneities, obstructions, or the desire to monitor a specific location. Additional discussion related to monitoring point placement is found in Section 5.0, Test Procedures.

4.2.2 Depth of Monitoring Points

In general, each monitoring point will be screened to at least 3 depths. The deepest screen will be placed either at or near the bottom of contamination if a water table is not encountered, or a minimum of 2 to 3 ft above the water table if it is encountered. Consideration will be given to potential seasonal water table fluctuations and soil type in finalizing the depth. In a more permeable soil the monitoring point can be screened closer to the water table. In a less permeable soil it must be screened further above the water table. The shallowest screen will normally be 3 to 5 ft below land surface. The intermediate screen will be placed at a reasonable interval at a depth corresponding to the center to upper ¼ of the depth of the vent well screen.

As an example, in a sandy soil with groundwater at 30 ft and a vent well screened from 17.5 to 27.5 ft below land surface, reasonable screened depths for the monitoring points would be 28 ft, 22.5 ft, and 3 ft. For sites with vent wells deeper than 30 ft, more depths will be screened; for example, if the vent well is screened from 30 to 100 ft, typical monitoring point screened depths will be 3, 20, 30, 40, 50, 60, 70, 80, 90, and 100 ft.

It will be necessary in some cases to add additional screened depths to ensure a well-oiled soil is encountered, to monitor differing stratigraphic intervals, or to adequately monitor deeper sites with broadly screened vent wells. If air injection is being considered in the bioventing test, a monitoring point must be located between the vent well and any buildings that may be at risk to assure that they are well beyond the radius of influence.

TABLE 4-1. Recommended Spacing for Monitoring Points

Soil Type	Depth to Top of Vent Well Screen (ft)(1)	Spacing Interval (ft)(2)
Coarse Sand	5	5-10-20
	10	10-20-40
	>15	20-30-60
Medium Sand	5	10-20-30
	10	15-25-40
	>15	20-40-60
Fine Sand	5	10-20-40
	10	15-30-60
	>15	20-40-80
Silts	5	10-20-40
	10	15-30-60
	>15	20-40-80
Clays	5	10-20-30
	10	10-20-40
	>15	15-30-60

(1) Assuming 10 ft of vent well screen, if more screen is used, the >15-ft spacing will be used.

(2) Note that monitoring point intervals are based on a venting flow rate range of 1 cfm/ft screened interval for clays to 3 cfm/ft screened interval for coarse sands.

4.2.3 Construction of Monitoring Points

Most state and local regulatory agencies do not regulate unsaturated zone soil gas monitoring point construction. Nevertheless, prior to construction it is necessary to check with regulators to assure compliance with any regulations that may exist.

Monitoring point construction will vary depending on the depth of drilling and the drilling technique. Basically, the monitoring points will consist of a small-diameter ¼-in. tube to the specified depth with a screen of approximately 6 in. in length and ½ to 1 in. in diameter. In shallow hand-augered installations, rigid tubing (i.e., Schedule 80 ¼" PVC) terminating in the center of a gravel or sand pack may be adequate. The gravel or sand pack will normally extend for an interval of 1 to 2 ft with the screen centered. In low-permeability soils, a larger gravel pack may be desirable. In wet soils a longer gravel pack with the screen near the top may be desirable. A bentonite seal at least 2 ft thick is normally required above and below the gravel pack. Figure 4-2 shows a typical installation.

Tubes will be used to collect soil gas for CO_2 and O_2 analysis in the 0.25% range, and for JP-4 hydrocarbons in the 100 ppm range or higher. The tubing material must have sufficient strength and be nonreactive. Sorption and gas interaction with the tubing materials have not been significant problems for this application. If a monitoring point will be used to monitor specific organics in the low ppm or ppb range, teflon or stainless steel may be necessary. However, this will not normally be the case.

All tubing from each monitoring point will be finished with quick-connect couplings and will be labeled twice. Each screened depth will be labeled with a name as follows:

[Code for Site] — [Code for Monitoring Point] — [Depth to Center of Screened Interval].

For example site #2 at Millersworth AFB the labels are:

M2-A-3	(3 ft deep)	Monitoring Point A, Closest to the vent well
M2-A-15	(15 ft deep)	
M2-A-25	(25 ft deep)	
M2-B-3	(3 ft deep)	Monitoring Point B, Intermediate from vent well
M2-B-15	(15 ft deep)	
M2-B-27	(27 ft deep)	
M2-C-3	(3 ft deep)	Monitoring Point C, Farthest from vent well
M2-C-14	(14 ft deep)	
M2-C-23	(23 ft deep)	

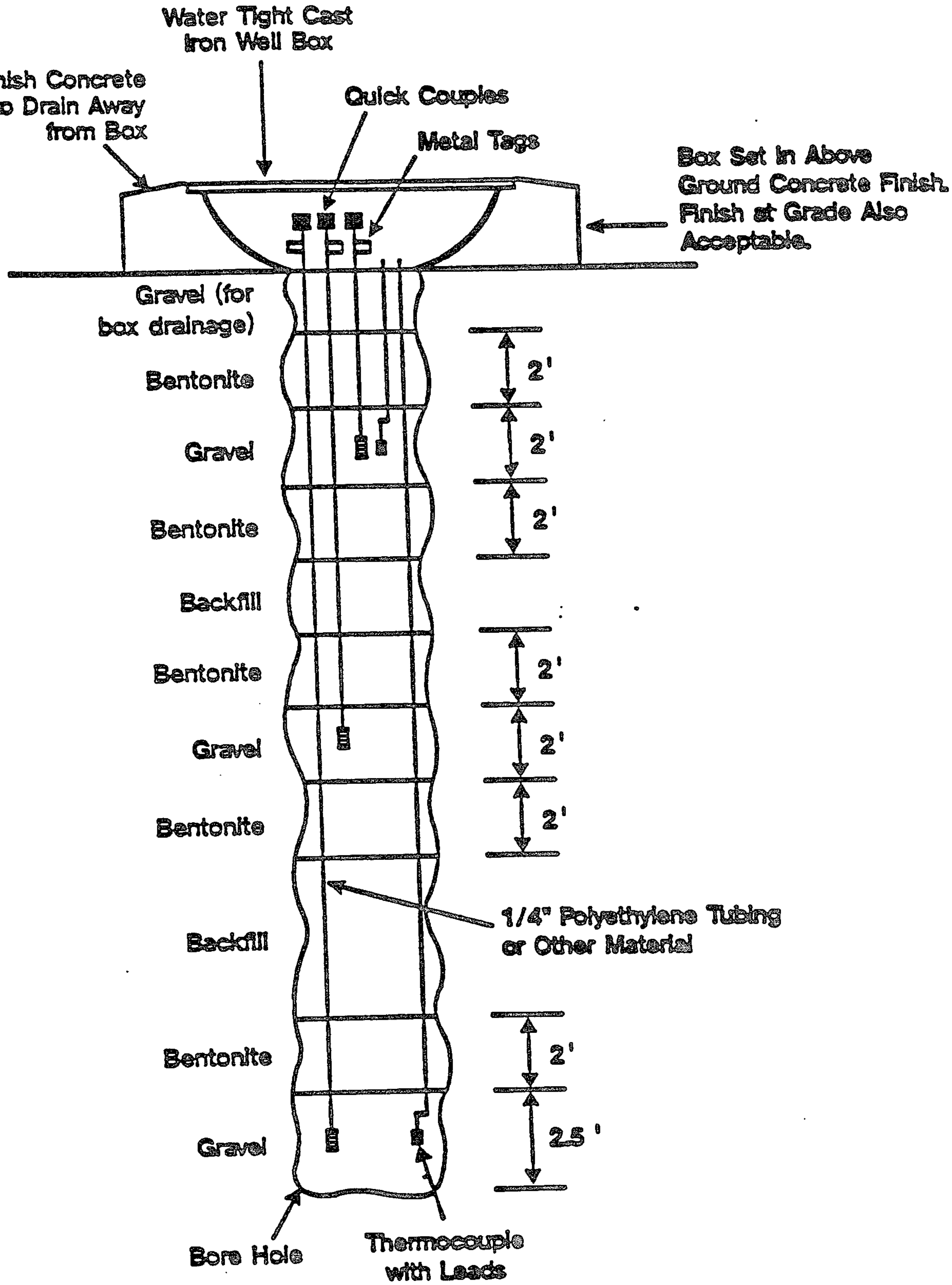

Figure 4-2. Typical Monitoring Point Construction Detail.
(Dimensions will vary for specific installations.)

In M2, the M is for Millersworth AFB, and the 2 is for site #2 at Millersworth. The tubing will be labeled with a metal tag firmly attached or directly by engraving or in waterproof ink. Or instead of the metal tag, a metal plate will be placed at the bottom of the monitoring point compartment with holes drilled for each tube. The metal plate will then be engraved, identifying each tube where it passes through the plate. If this method is used, the tube itself must still be labeled with ink or by engraving. The label will be placed close to the ground so that if the tube is damaged, the label will likely survive.

The top of each monitoring point will be labeled to be visible from above. This will be done either by writing in the concrete or with spray paint.

The monitoring points will be finished by placement in a watertight cast iron well box. The well box will be placed either aboveground in a concrete pad or at grade, also in concrete. The box will be drained to prevent water accumulation.

4.2.4 Thermocouples

Two thermocouples will be installed at each site. These will be installed at the monitoring point closest to the vent well and, as shown in Figure 4-2, at the depth of the shallowest and deepest screen. Thermocouples used are either J or K type. The thermocouple wires will be labeled using the same system as for the tubings, except that a two-letter word, TC, is added to the identification label (e.g., M2-A-3-TC, for the thermocouple installed at the second Millersworth AFB site monitoring point A at the 3-ft depth).

4.3 Background Well

In addition to the vent well and the monitoring points installed in contaminated soils, a background well will be installed in uncontaminated soil to monitor the background respiration of natural organic matter. Soil gas in uncontaminated soil generally has O_2 levels between 15 and 20% and CO_2 levels between 1 and 5%. The background well will be similar in construction to the vent well (Figure 4-1), except that the length of the screen will be approximately 5 ft.

To the extent possible, the screen of the background well will be located at a depth similar to that of the monitoring points and in the same stratigraphic formation. For sites deeper than 20 ft, the screen portion of the background well will be placed at 20 to 25 feet. For depths less than 20 ft, the screen portion of the background well will be placed between 5 and 15 ft.

4.4 Blower System

The type and size of blower used on a test site will be determined based upon the soil type, depth and area of contamination, and available power. In an attempt to reduce the number of blower units in the pilot test inventory and to standardize piping and instrumentation, two typical blowers are specified:

Blower One

Application:
Contaminated interval in sandy soils and mixed sandy/silt and sandy/clay soils.

Typical Specifications:
- Explosion-proof regenerative blower
- 20 to 90 scfm at 100" to 20" H_2O, respectively
- 3-HP explosion-proof motor
- Single-phase 230-volt power source

Blower Two

Application:
Predominantly silt and clay soils.

Typical Specifications:
- Explosion-proof pneumatic blower
- 50 scfm at 200" H_2O.
- 5-HP explosion-proof motor
- Single-phase 230-V power source.

Each blower will be fitted with mounting brackets and pipe fittings to make it compatible with the basic blower systems shown in Figures 4-3 and 4-4. Explosion-proof blowers and motors are required when soil gas extraction is used. Explosion-proof equipment may be required for air injection systems as well.

The blower system will be instrumented to monitor blower performance and to provide test data such as the vent well pressure (Pw) and the gas stream flow rate (Q) adjusted for air density. Using these data and pressure data from each soil gas monitoring point, k and R_I can be estimated.

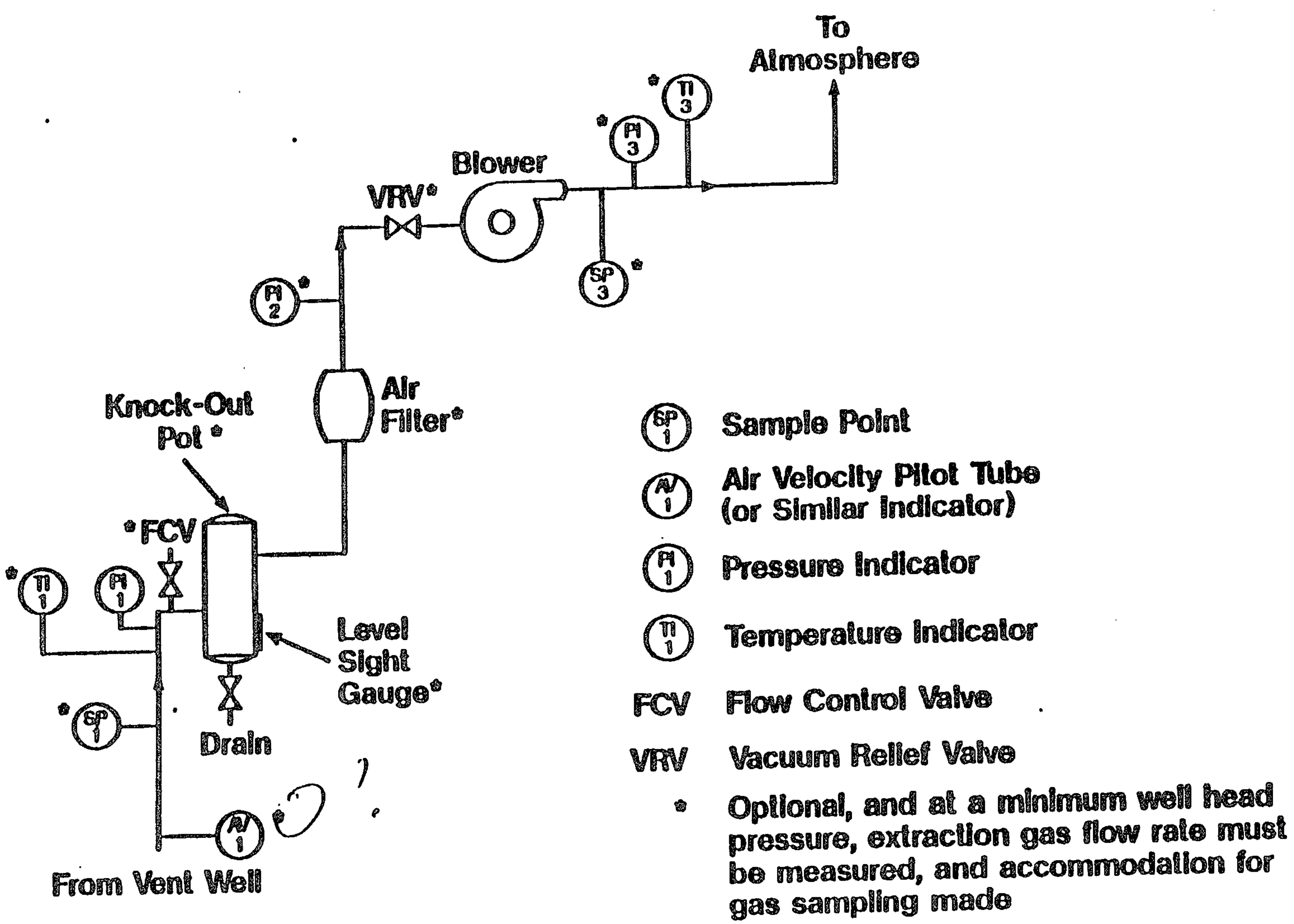

Figure 4-3. Soil Gas Permeability Blower System Instrumentation Diagram for Soil Gas Extraction.

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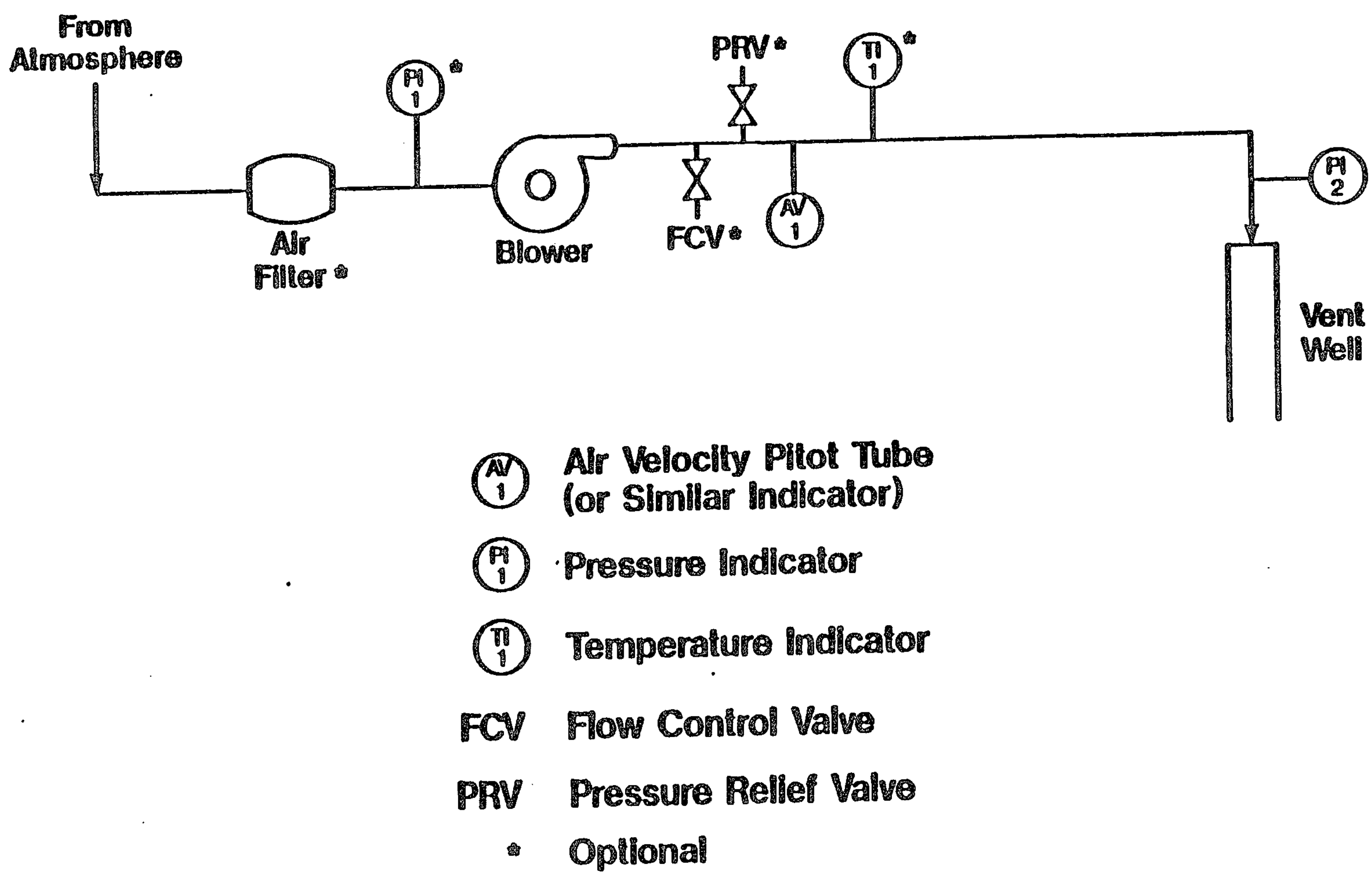

Figure 4-4. Soil Gas Permeability Blower System Instrumentation Diagram for Air Injection.

KA/Drg/3-02

4.5 Field Instrumentation and Measurements

Sections 4.5.1 through 4.5.6 discuss the equipment used for measurements. Figures supplement the text.

4.5.1 Oxygen and Carbon Dioxide

Gaseous concentrations of CO_2 and O_2 will be analyzed using a GasTech model 3252OX CO_2/O_2 analyzer or equivalent. Two analyzers will be used. Both meters read percent oxygen from 0 to 25%. One meter has a CO_2 range of 0 to 5%, and the other has a range of 0 to 25% CO_2.

The battery charge level will be checked to ensure proper operation. The air filters will be checked and, if necessary, be cleaned or replaced before the experiment is started. The instrument will be turned on and equilibrated for at least 30 minutes before conducting calibration or obtaining measurements. The sampling pump of the instrument will be checked to ensure that it is functioning. Low flow of the sampling pump can indicate that the battery level is low or that some fines are trapped in the pump or tubing.

Meters will be calibrated each day prior to use against purchased CO_2 and O_2 calibration standards. These standards will be selected to be in the concentration range of the soil gas to be sampled. The CO_2 calibration will be performed against atmospheric CO_2 (0.05%) and a 5% standard. The O_2 will be calibrated using atmospheric O_2 (20.9%) and against a 5% and 0% standard. Standard gases will be purchased from a specialty gas supplier. To calibrate the instrument with standard gases, a Tedlar™ bag (capacity ~ 1 l) is filled with the standard gas, and the valve on the bag is closed. The inlet nozzle of the instrument is connected to the Tedlar™ bag, and the valve on the bag is opened (see Figure 4-4). The instrument is then calibrated against the standard gas according to the manufacturer's instructions. Next, the inlet nozzle of the instrument is disconnected from the Tedlar™ bag and the valve on the bag is shut off. The instrument will be rechecked against atmospheric concentration. If recalibration is required, the above steps will be repeated.

4.5.2 Hydrocarbon Concentration

Petroleum hydrocarbon concentrations will be analyzed using a GasTech Trace-Techtor™ hydrocarbon analyzer (or equivalent) with range settings of 100 ppm, 1,000 ppm, and 10,000 ppm. The analyzer will be calibrated against two hexane calibration gases (500 ppm and 4,400 ppm). The Trace-Techtor™ has a dilution fitting that can be used to calibrate the instrument in the low-concentration range.

Calibration of the GasTech Trace-Techtor™ is similar to the GasTech Model 32402X, except that a mylar bag is used instead of a Tedlar™ bag. The O_2 concentration must be above 10% for the Trace-Techtor™ analyzer to be accurate. When the O_2 drops below 10%, a dilution fitting must be added to provide adequate oxygen for analysis.

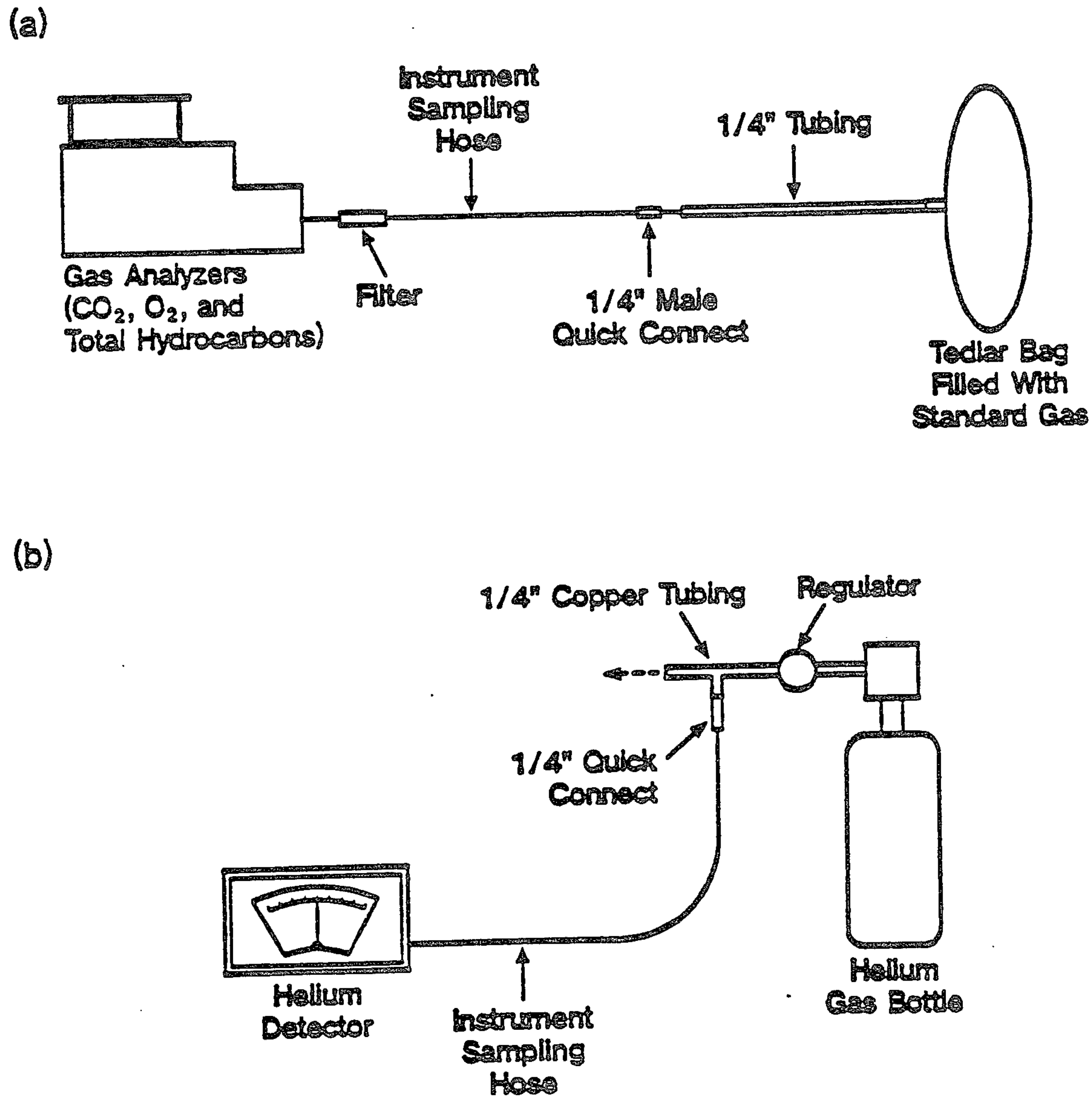

Figure 4-5. Schematic Setup for Calibration of Soil Gas Instruments.
(a) CO_2, O_2, and Total Hydrocarbon Analyzers.
(b) Helium Detector.

Hydrocarbon concentrations can also be determined with a flame ionization detector (FID), which can detect low (below 100 ppm) concentrations. A photoionization detector (PID) is *not* acceptable.

4.5.3 Helium Monitoring

Helium in the soil gas will be measured with a Marks Helium Detector Model 9821 or equivalent with a minimum sensitivity of 0.01%. Calibration of the helium detector follows the same basic procedure described for oxygen calibration, except that the setup for calibration is different (see Figure 4-5). Helium standards used are 100 ppm (0.01%), 5,000 ppm (0.5%), and 10,000 ppm (1%).

4.5.4 Temperature Monitoring

In situ soil temperature will be monitored using Omega Type J or K thermocouples (or equivalent). The thermocouples will be connected to an Omega OM-400 Thermocouple Thermometer (or equivalent). Each thermocouple will be calibrated against ice water and boiling water by the contractor before field installation.

4.5.5 Pressure/Vacuum Monitoring

Air pressure during injection for the in situ respiration test will be measured with a pressure gauge with a minimum range of 0 to 30 psia. Changes in soil gas pressure during the air permeability test will be measured at monitoring points using Magnehelic™ or equivalent gauges. Tygon™ or equivalent tubing will be used to connect the pressure/vacuum gauge to the quick-disconnect on the top of each monitoring point. Similar gauges will be positioned before and after the blower unit to measure pressure/vacuum across the blower and at the head of the venting well. Pressure/vacuum gauges are available in a variety of pressure/vacuum ranges, and the same gauge can be used to measure either vacuum or pressure by simply switching inlet ports. Gauges are sealed and calibrated at the factory and will be rezeroed before each test. The following pressure ranges (in inches H_2O) will typically be available for this field test:

0-1", 0-5", 0-10", 0-20", 0-50", 0-100", and 0-200"

4.5.6 Airflow

Airflow measurements will be taken for both the air permeability test and the respiration test. These measurements are described in Sections 4.5.6.1 and 4.5.6.2.

4.5.6.1 Airflow Measurement — Air Permeability Test

During the air permeability test an accurate estimate of flow (Q) entering or exiting the vent well is required to determine k and R_I. Several airflow measuring devices are acceptable for this test procedure.

Pitot tubes or orifice plates combined with an inclined manometer or differential pressure gauge are acceptable for measuring flow velocities of 1,000 ft/min or greater (~20 scfm in a 2-in. pipe). For lower flow rates, a large rotometer will provide a more accurate measurement. If an inclined manometer is used, the manometer must be rezeroed before and after the test to account for thermal expansion/contraction of the water. Devices to measure static and dynamic pressure must also be installed in straight pipe sections according to manufacturer's specifications. All flow rates will be corrected to standard temperature and ambient pressure (altitude) conditions.

4.5.6.2 Airflow Measurement — Respiration Test

Prior to initiating respiration tests at individual monitoring points, air will be pumped into each monitoring point using a small air compressor as described in Section 5.7. Airflow rates of 1 to 1.5 cfm will be used, and flow will be measured using a Cole-Palmer Variable Area Flowmeter No. N03291-4 (or equivalent). Helium will be introduced into the injected air at a 1% concentration. A helium flow rate of approximately 0.01 to 0.015 cfm (0.6 to 1.0 cfm) will be required to achieve this concentration. A Cole-Palmer Model L-03291-00 flowmeter or equivalent will be used to measure the flow rate of the helium feed stream.

5.0 TEST PROCEDURES

5.1 Location of Optimum Test Area

A soil gas survey will be conducted to locate an optimum site for the vent well and the soil gas monitoring points. Ideally, the vent well and monitoring points will be located in well-oiled soils where the O_2 is depleted and the CO_2 levels are elevated (see discussion in 4.2). If at least three monitoring point screens are not located in the most contaminated soils, then the in situ respiration test may not provide adequate information on the biodegradation rates for the site.

5.1.1 Soil Gas Survey (for contamination < 20 ft)

A soil gas survey will be conducted prior to locating the vent well and monitoring points at sites with relatively shallow groundwater where soils are penetrable to a depth of within 5 ft of the water table using hand-driven gas probes. The survey will not be a complete site soil gas survey to fully delineate contamination.

Accessibility to the site will be confirmed, along with possible restrictions that may hamper the tests. Existing groundwater and soil gas monitoring wells near the test area will be identified. Groundwater will be checked for free floating product, and soil gas from any existing monitoring points or wells will be analyzed for O_2, CO_2, and total hydrocarbons before proceeding with the soil gas survey. To assist in the soil gas survey, a simple sampling grid will be established using existing monitoring wells or prominent landmarks for identification.

Soil gas sampling will be conducted using small-diameter (~⅝-inch OD) stainless steel probes (KVA Associates or equivalent) with a slotted well point assembly. The maximum depth for hand-driven probes will typically be 10 to 15 ft, depending on soil texture. In some dense silts or clays, penetration of the soil gas probe will be less, while in some unconsolidated sands, deeper penetration may be possible. At a given location on the grid, a probe will be driven (manually or with a power hammer) to a depth determined by preliminary review of the site contamination documents. Soil gas at this depth will be analyzed for O_2, CO_2, and total hydrocarbons. The probe will then be driven deeper, and the soil gas will be measured. For a typical site with a depth to groundwater of 9 ft, soil gas will be measured at depths of 2.5 ft, 5 ft, and 7.5 ft.

The main criterion for selecting a suitable test site is that the microbial activity should be oxygen-limited. Under such conditions, the O_2 level will be low (usually 0 to 2%), CO_2 will be high (typically 5 to 20%, depending on soil type), and hydrocarbon content will be high (> 10,000 ppm).

An uncontaminated site also will be located to be used as an experimental control to monitor background respiration of natural organic matter and inorganic

sources of CO_2. Typical O_2 and CO_2 levels at an uncontaminated site are 15 to 20% and 1 to 5%, respectively. The hydrocarbon content in the soil gas of a contaminated site is generally below 100 ppm.

Prior to sampling, soil gas probes will be purged with a sample pump. To determine adequate purging time, soil gas concentrations will be monitored until the concentrations stabilize. This will not always be possible, particularly when shallow soil gas samples are being collected, as atmospheric air may be drawn into the probe and produce false readings. When shallow soil gas samples are collected, air withdrawal will be kept to a minimum. Figure 5-1 shows a typical setup for monitoring soil gas.

5.1.2 Exploratory Boring in Deep Soils

On sites where contamination extends to depths greater than 20 ft, exploratory borings will be used to ensure that the vent well and monitoring points are located in fuel-contaminated soils. Exploratory borings that encounter significant fuel contamination will then be completed and used as vent wells or monitoring points.

A hollow-stem auger will be used to advance the boring, and drill cuttings will be visually checked and analyzed with a GasTech Trace-Techtor™ (or equivalent) hydrocarbon analyzer, an equivalent explosimeter, or a FID, to determine the relative fuel contamination of each 2- to 3-ft interval. Drill cuttings will be inspected at each contaminated interval selected for monitoring point installations.

As the boring advances beyond 20 ft, a split-spoon sampling device will be recommended for sampling at 5-ft intervals. Split-spoon samples will be visually checked for fuel contamination and screened for volatile emissions by passing a hydrocarbon analyzer slowly over the open split spoon.

The purpose of this simple monitoring technique will be to provide air monitoring for worker health and safety, to rapidly locate the interval of highest contamination, and to attempt to locate the maximum depth of contamination at each site. A geologic driller's log will be kept to identify changes in lithology, depths of apparent fuel contamination, and sample locations. Exploratory borings will also be required to locate a clean area for installing the background monitoring point. Careful inspection of drill cuttings and volatile hydrocarbon monitoring will be required to ensure that soils in the control area are free of fuel hydrocarbons.

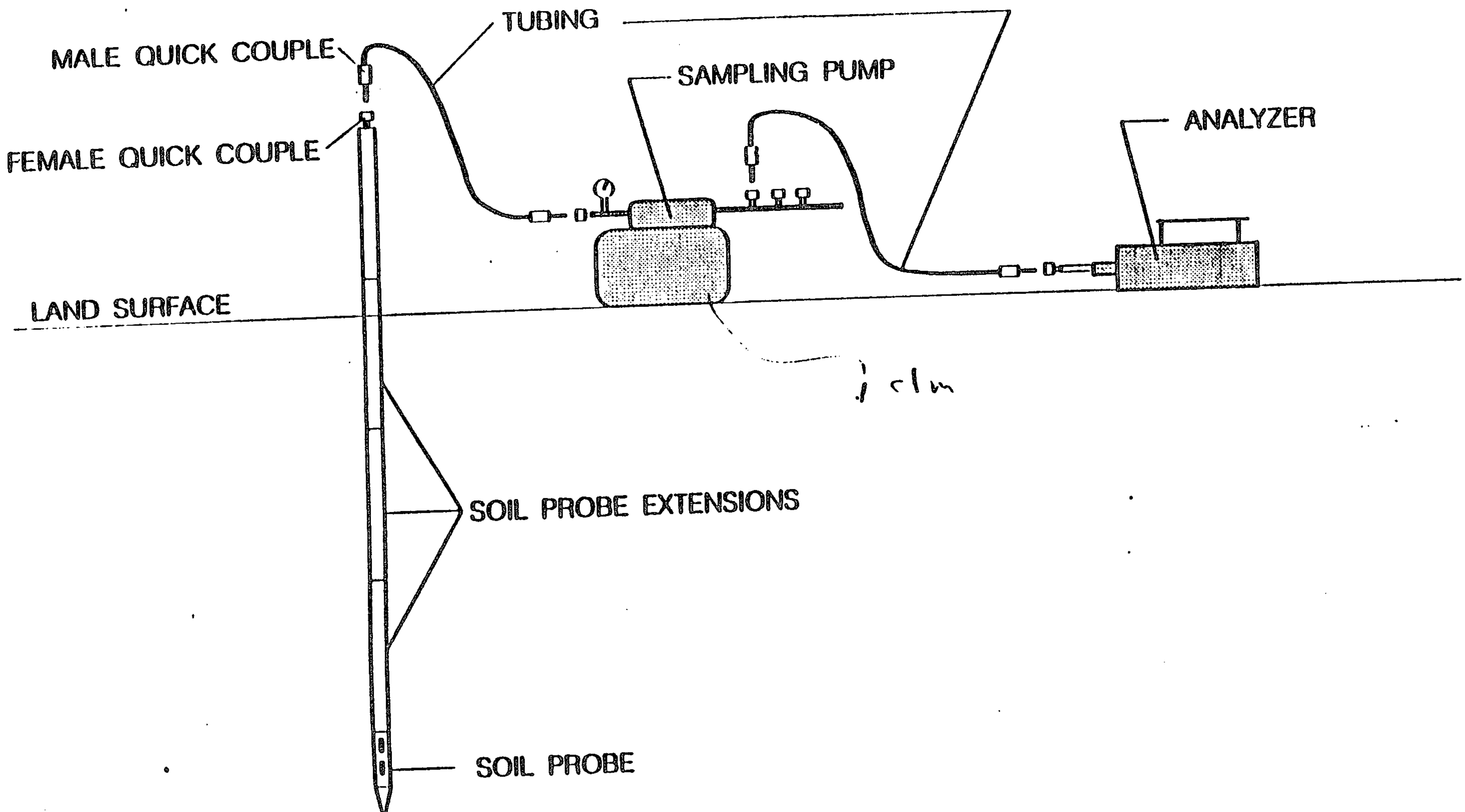

Figure 5-1. Schematic Diagram of Soil Gas Sampling Using the Stainless Steel Soil Gas Probe.

5.2 Drilling and Installation of the Vent Well

Based on a review of available site characterization data, a preliminary location will be proposed for the vent well. Following the soil gas survey and/or exploratory boring, a final vent well location will be determined. If soils were proved to be sufficiently contaminated, the exploratory boring will be completed as the vent well. Soil samples will be collected at a minimum interval of 5 ft in the vent well boring following the procedures outlined in Section 5.5. Siting and construction of the vent well will follow the criteria provided in Section 4.1.

5.3 Drilling and Installation of Monitoring Points

Based on the location of the vent well and available site characterization data, the monitoring points will be located at points where sufficient data for the air permeability tests can be obtained and, at the same time, they can be used for the in situ respiration test. Table 4-1 will be used as a guide to locate the monitoring points in relation to the location of the vent well. The location of the monitoring points will also take into consideration the long-term bioventing test that will be conducted after the in situ respiration test. The monitoring points will generally be located in a contaminated area. Screens for the monitoring points will have the same slot sizes as those for the vent well (see discussion in Section 4.2).

When possible, the monitoring points will be placed in hand-augered borings or in borings augered with a small portable drill. At deeper sites, it will be necessary to hire a driller for both the monitoring points and the vent well. When a drill rig is used, a hollow-stem auger will most likely be used. A smaller ID auger will be used, as required, for the vent well installation. Also as required, a solid auger will be used in shallow or cohesive soils.

5.4 Background Well Installation

A background well will be installed in an uncontaminated location to obtain soil gas measurements of O_2 and CO_2 concentrations to monitor background respiration. The well will be constructed in a manner similar to the vent well, except that it will normally be 1 in. in diameter with a screen length of 5 ft. At sites deeper than 20 ft, the screened portion of the background well will be placed at 20 to 25 ft, so long as it is screened in the same geological formation as the vent well. Normally, deeper screening will be required only if necessary to intercept the vented formation.

5.5 Collection of Soil Samples

A minimum of three to four soil samples will be collected from each site and analyzed for physical/chemical characteristics, including nutrient concentration. At least one representative sample of each contaminated soil type will be collected. It is

important that samples for nutrient analyses be collected from a contaminated zone; otherwise, if fixation has already occurred, the nitrogen concentration may not be representative. Soil samples will be collected from the exploratory boring or from the borings for the vent well or monitoring points. Soil samples will be collected from cuttings if the borings are shallow, by hand from a hand-augered hole, or with a split-spoon sampler. Enough soil will be collected to fill a 500-ml polyethylene or glass container. The container will be sealed with a teflon-lined cap and then placed in a cooler for shipment. Special procedures for preserving the sample will not be required, as only inorganics and the physical properties of the soil will be analyzed. Each soil sample will be labeled to identify the site, boring location and depth, and time of collection.

Chain-of-custody forms will accompany each shipment to the laboratory. The soil samples will be analyzed for the following parameters:

- pH
- total kjeldahl nitrogen (TKN)
- total phosphorus
- alkalinity
- particle size analysis
- total iron
- moisture content.

In addition to the chain-of-custody forms, each sample will be logged into the project record book along with a complete description of where and how it was collected. Each sample will be labeled with an identification code corresponding to its sampling location. The code will follow the system described for labeling the monitoring points in Section 4.2.3 as follows:

[Code for Site] — [Code for Location] — [Depth]

Location codes will include the abbreviations VW for vent well, MP for monitoring point, BG for background well, or EB for an exploratory boring or other boring not completed as a vent well, monitoring point, or background well. For the example site #2 at Millersworth AFB the following codes might be used:

- M2—VW—12 for a sample from site #2 at Millersworth AFB from a depth of 12 ft from the vent well boring

- M2—MPC—28 for a sample from a depth of 28 ft from the monitoring point C boring

- M2—BG—4 for a sample from a depth of 4 ft from the background boring

- M2—EB2—20 for a sample from a depth of 20 ft from the second exploratory boring, which was subsequently grouted and not completed as a well or monitoring point.

5.6 Soil Gas Permeability Test Procedures

This section describes the field procedures that will be used to gather data to determine k and to estimate R_I. The Appendix provides an example data set and calculations for the radius of influence using the dynamic and steady-state solution methods.

Prior to initiating the soil gas permeability test, the site will be examined for any wells (or other structures) that will not be used in the test but may serve as vertical conduits for gas flow. These will be sealed to prevent short-circuiting and to ensure the validity of the soil gas permeability test.

5.6.1 System Check

Before proceeding with this test, soil gas samples will be collected from the vent well, the background well, and all monitoring points, and analyzed for O_2, CO_2, and volatile hydrocarbons. After the blower system has been connected to the vent well and the power has been hooked up, a brief system check will be performed to ensure proper operation of the blower and the pressure and airflow gauges, and to measure an initial pressure response at each monitoring point. This test is essential to ensure that the proper range of Magnehelic™ gauges are available for each monitoring point at the onset of the soil gas permeability test. Generally, a 10- to 15-minute period of air extraction or injection will be sufficient to predict the magnitude of the pressure response, and the ability of the blower to influence the test volume.

5.6.2 Soil Gas Permeability Test

After the system check, and when all monitoring point pressures have returned to zero, the soil gas permeability/radius of influence test will begin. Two people will be required during the initial hour of this test. One person will be responsible for reading the Magnehelic™ gauges, and the other person will be responsible for recording pressure (P′) vs. time on the example data sheet (see Appendix Table A-2). This will improve the consistency in reading the gauges and will reduce confusion. Typically, the following test sequence will be followed:

1. Connect the Magnehelic™ gauges to the top of each monitoring point with the stopcock opened. Return the gauges to zero.

2. Turn the blower unit on, and record the starting time to the nearest second.

3. At 1-minute intervals, record the pressure at each monitoring point beginning at $t = 60$ s.

4. After 10 minntes, extend the interval to 2 minutes. Return to the blower unit and record the pressure reading at the well head, the temperature readings, and the flow rate from the vent well.

5. After 20 minutes, measure P' at each monitoring point in 3-minute intervals. Continue to record all blower data at 3-minute intervals during the first hour of the test.

6. Continue to record monitoring point pressure data at 3-minute intervals until the 3-minute change in P' is less than 0.1 in. of H_2O. At this time, a 5- to 20-minute interval can be used. Review data to ensure accurate data were collected during the first 20 minutes. If the quality of these data is in question, turn off the blower, allow all monitoring points to return to zero pressure, and restart the test.

7. Begin to measure pressure at any groundwater monitoring points that have been converted to monitoring points. Record all readings, including zero readings and the time of the measurement. Record all blower data at 30-minute intervals.

8. Once the interval of pressure data collection has increased, collect soil gas samples from monitoring points and the blower exhaust (if extraction system), and analyze for O_2, CO_2, and hydrocarbons. Continue to gather pressure data for 4 to 8 hours. The test will normally be continued until the outermost monitoring point with a pressure reading does not increase by more than 10% over a 1-hour interval.

9. Calculate the values of k and R_I with the data from the completed test using the HyperVentilate™ computer program. The Appendix shows sample calculation methods for determining k and R_I.

5.6.3 Post-Permeability Test Soil Gas Monitoring

Immediately after completion of the permeability test, soil gas samples will be collected from the vent well, the background well, and all monitoring points, and analyzed for O_2, CO_2, and hydrocarbons. If the O_2 concentration in the vent well has increased by 5% or more, O_2 and CO_2 will be monitored in the vent well in a manner similar to that described for the monitoring points in the in situ respiration test. (Initial monitoring may be less frequent.) The monitoring will provide additional in situ respiration data for the site.

5.7 In Situ Respiration Test

The in situ respiration test will be conducted using four screened intervals of the monitoring points and a background well. The results from this test will determine if in situ microbial activity is occurring and if it is O_2-limited.

5.7.1 Test Implementation

Air with 1 to 2% helium will be injected into the monitoring points and background well. Following injection, the change of O_2, CO_2, total hydrocarbon, and helium in the soil gas will be measured over time. Helium will be used as an inert tracer gas to assess the extent of diffusion of soil gases within the aerated zone. If the background well is screened over an interval of greater than 10 ft, the required air injection rate may be too high to allow helium injection. The background monitoring point will be used to monitor natural degradation of organic matter in the soil. A schematic of the apparatus to be used in the in situ respiration test is presented in Figure 2-9.

The O_2, CO_2, and total hydrocarbon levels will be measured at the monitoring points before air injection. Normally, air will be injected into the ground for at least 20 hours at rates ranging from 60 to 100 cfh. Blowers to be used will be diaphragm compressors Model 4Z024 from Grainger (or equivalent) with a nominal capacity of 100 cfh at 10 psi. The helium used as a tracer will be 99% or greater purity, which is available from most welding supply stores. The flow rate of helium will be adjusted to 0.6 to 1.0 cfh to obtain about 1% in the final air mixture which will be injected into the contaminated area. Helium in the soil gas will be measured with a Marks Helium Detector Model 9821 (or equivalent) with a minimum sensitivity of 0.01%.

After air and helium injection is completed, the soil gas will be measured for O_2, CO_2, helium, and total hydrocarbon. Soil gas will be extracted from the contaminated area with a soil gas sampling pump system similar to that shown in Figure 5-1. Typically, measurement of the soil gas will be conducted at 2, 4, 6, and 8 hours and then every 4 to 12 hours, depending on the rate at which the oxygen is utilized. If oxygen uptake is rapid, more frequent monitoring will be required. If it is slower, less frequent readings will be acceptable.

At shallow monitoring points, there is a risk of pulling in atmospheric air in the process of purging and sampling. Excessive purging and sampling may result in erroneous readings. There is no benefit in over sampling, and when sampling shallow points, care will be taken to minimize the volume of air extraction. In these cases, a low-flow extraction pump of about 2 to 4 cfh will be used. Field judgment will be required at each site in determining the sampling frequency. Table 5-1 provides a summary of the various parameters which will be measured and their frequency.

The in situ respiration test will be terminated when the oxygen level is about 5%, or after 5 days of sampling. The temperature of the soil before air injection and after the in situ respiration test will be recorded.

5.7.2 Data Interpretation

Data from the in situ respiration/air permeability test will be summarized, and the O_2 utilization rates, air permeability, and R_I will be computed. Further details on data interpretation are presented in Sections 5.7.2.1 and 5.7.2.2.

5.7.2.1 Oxygen Utilization

Oxygen utilization rates will be determined from the data obtained during the bioventing tests. The rates will be calculated as the percent change in O_2 over time. Table 5-2 contains the two sets of sample data which are illustrated in Figure 5-2. The O_2 utilization rate is determined as the slope of the O_2% vs. time line. A zero-order respiration rate as seen in the Fallon NAS data is typical of most sites; however, a fairly rapid change in oxygen levels may be seen as in the data from Kenai, Alaska. In the later, the oxygen utilization rate was obtained from the initial linear portion of the respiration curve.

To estimate biodegradation rates of hydrocarbon from the oxygen utilization rates, a stoichiometric relationship for the oxidation of the hydrocarbon will be used. Hexane will be used as the representative hydrocarbon, and the stoichiometric relationship used to determine degradation rates will be:

$$C_6H_{14} + 9.5\ O_2 \rightarrow 6CO_2 + 7H_2O$$

Based on the utilization rates (change of oxygen [%] per day), the biodegradation rate in terms of mg of hexane-equivalent per kg of soil per day will be estimated using the following equation.

$$K_B = -K_o\, A\, D_o\, C/100 \qquad (1)$$

where:

K_B = biodegradation rate (mg/kg day)
K_o = oxygen utilization rate (percent per day)
A = volume of air/kg of soil (l/kg)
D_o = density of oxygen gas (mg/l)
C = mass ratio of hydrocarbon to oxygen required for mineralization.

TABLE 5-1. Parameters to be Measured for the In Situ Respiration Tests

Parameter/Media	Suggested Method	Suggested Frequency	Instrument Sensitivity (Accuracy)
Carbon dioxide/soil gas	Infrared adsorption method, GasTech Model 32520X (0 to 5% and 0 to 25% carbon dioxide)	Initial soil gas sample before pumping air, immediately after pump shut off, every 2 hours for the first 8 hours, and then every 8 to 10 hours	±0.2%
Oxygen/soil gas	Electrochemical cell method, GasTech Model 32520X (0 to 21% oxygen)	Same as above	±0.5%
Total hydrocarbons (THC)/soil gas	GasTech hydrocarbon detector or similar field instrumentation	Initial soil gas sample before pumping air, then same as above if practical	±1 ppm
Helium	Marks Helium Detector Model 9821 or equivalent	Same as for carbon dioxide	±0.01%
Pressure	Pressure gauge (0 to 30 psia)	During air injection	0.5 psia
Flow rate/air	Flowmeter	Reading taken during air injection	±5 cfh

TABLE 5-2. Sample Data Set for Two In Situ Respiration Tests

Fallon NAS, Nevada (Test Well A2)			Kenai, Alaska (Test Well K_1)			
Time (Hours)	O_2(%)	CO_2(%)	Time (Hours)	O_2(%)	CO_2(%)	Helium
-23.5	0.05	20.4	-22.0	3.0	17.5	—
0	20.9	0.05	0	20.9	0.05	1.8
2.5	20.3	0.08	7.0	11.0	2.7	1.4
5.25	19.8	0.10	12.25	4.8	4.6	1.4
8.75	18.7	0.13	19.50	3.5	6.0	1.3
13.25	18.1	0.16	26.25	1.8	6.5	1.0
22.75	15.3	0.14	46.00	2.0	7.0	0.9
27.0	15.2	0.22				
32.5	13.8	0.14				
37.0	12.9	0.23				
46.0	11.2	0.22				
49.5	10.6	0.16				

Using several assumptions, values for A, D_o, and C can be calculated and substituted into equation 1. Assumptions used for these calculations are:

- Porosity of 0.3 (the air-filled porosity; in any given soil varies with moisture content in any given soil)
- Soil bulk density of 1,440 kg/m^3
- D_o oxygen density of 1,330 mg/l (varies with temperature, altitude, and atmospheric pressure)
- C, hydrocarbon-to-oxygen ratio of 1/3.5 from the above equation for hexane.

Based on the above assumed porosity and bulk density, the term A, volume of air/mg of soil, becomes 300/1,440 = 0.21. The resulting equation is:

$$K_B = -(K_o)(0.21)(1330)(1/3.5)/100 = 0.8\ K_o \quad (2)$$

This conversion factor, 0.8, was used by Hinchee et al. (1991b) in their calculations of biodegradation rates of hydrocarbons. Another way to estimate biodegradation rates is based on CO_2 generation rates, but as discussed in Section 2.3, this is less reliable than using O_2 utilization rates.

5.7.2.2 Helium Monitoring

Figures 5-3 and 5-4 show typical helium data for two test wells. The helium concentration at monitoring point S1 (Figure 5-3) at Tinker AFB started at 1.5% and after 108 hours had dropped to 1.1%, i.e., a fractional loss of ~0.25. In contrast, for Kenai K3 (Figure 5-4), the change in helium was rapid (a fractional drop of about 0.8 in 7 hours), indicating that there was possible short-circuiting at this monitoring point. This suggested that the data from this monitoring point were unreliable, and so the data were not used in calculating degradation rates.

As a rough estimate, diffusion of gas molecules is inversely proportional to the square root of the molecular weight of the gas. Based on the molecular weights of 4 and 32 g mol for helium and oxygen, respectively, helium diffuses about 2.8 times faster than oxygen. This translates into a fractional oxygen loss of ~0.095 for S1 of Tinker AFB, a minimal loss. The data from this monitoring point were used in the calculation rates. As a guide, data from tests where fractional helium loss is 0.4 or less over 100 hours, or an equivalent fractional oxygen loss of 0.15, are acceptable.

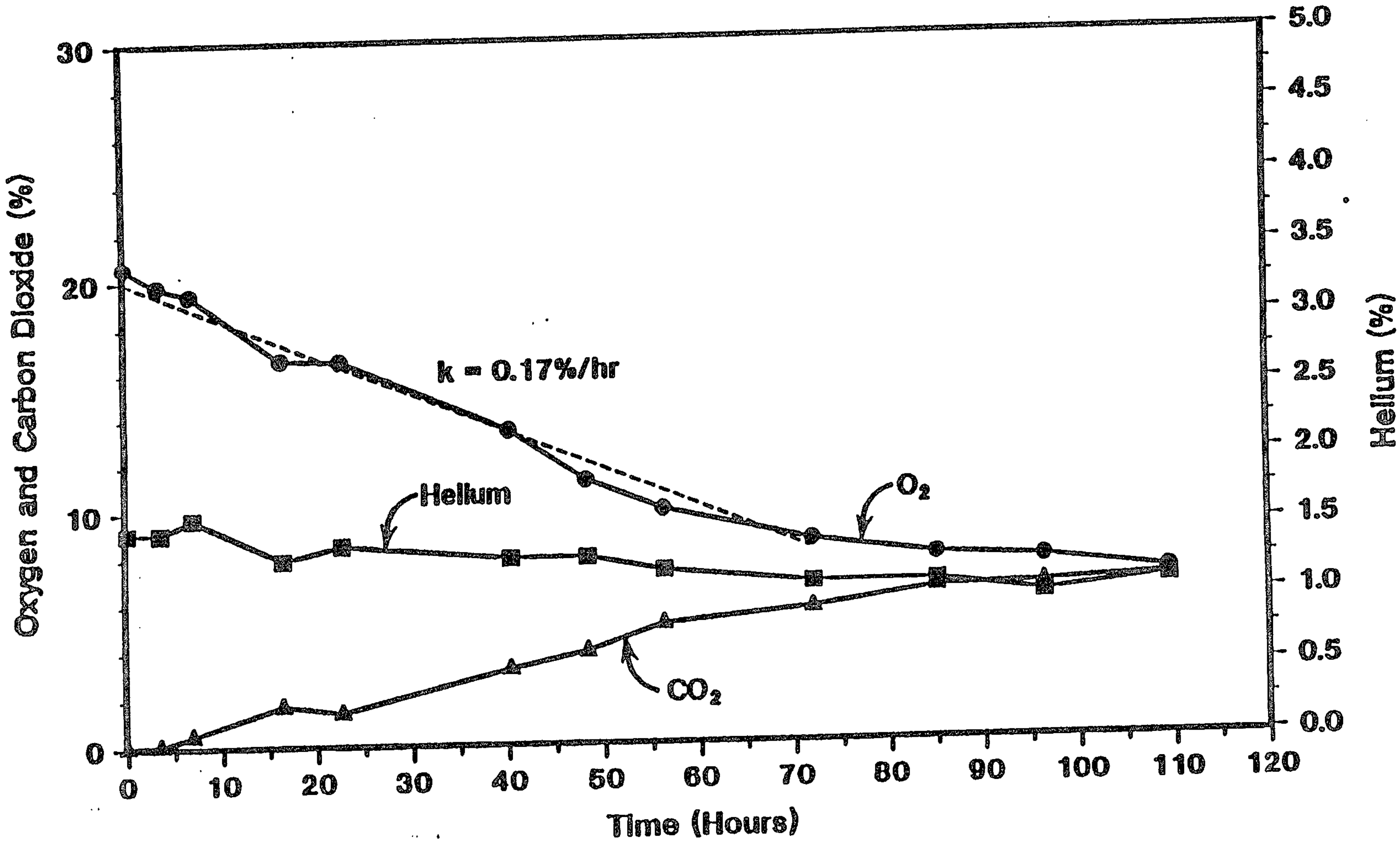

Figure 5-3. In Situ Respiration Test Results for Monitoring Point S1, Tinker AFB, Oklahoma.

KA/Org/3-03

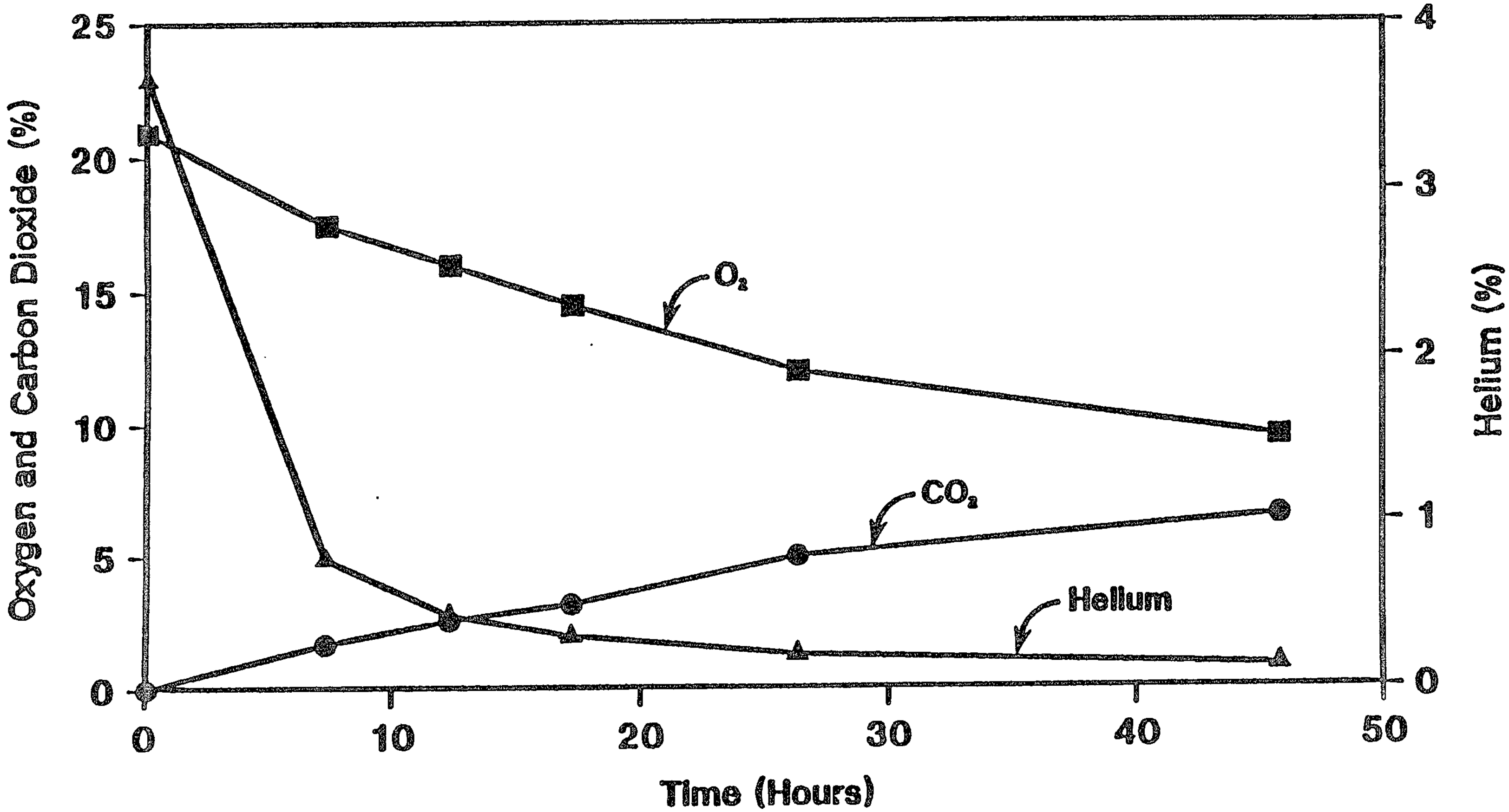

Figure 5-4. In Situ Respiration Test Results for Monitoring Point K3, Kenai, Alaska.

5.8 Bioventing Test

The bioventing test is the third and final part of the field treatability study and will consist of a longer term (6 months or more) air injection or withdrawal procedure. A blower will be installed immediately following completion of the air permeability and in situ respiration tests, and will be started before the field crew leaves the site. At some sites where regulatory approval is pending, the bioventing blower will be installed and started at a later date.

5.8.1 Criteria for Conducting the Bioventing Test

The contractor will plan on conducting the bioventing test at each site; however, at some sites the bioventing test may not be appropriate (e.g., where no bioremediation is stimulated). Upon completion of the soil gas permeability and the in situ respiration tests, the data will be analyzed and a decision will be made as to whether the bioventing test is to be implemented. This decision will be confirmed before the field crew leaves the site.

5.8.1.1 Air Permeability/Radius of Influence

The technology of soil venting has not advanced far enough to provide firm quantitative criteria for determining the applicability of venting based solely on values of k or R_I. In general, k must be sufficiently high to allow movement of oxygen in a reasonable time frame (1 or 2 days) from either the vent well, in the case of injection, or the atmosphere or uncontaminated soils, in the case of extraction. If such a flow rate cannot be achieved, O_2 cannot be supplied at a rate to match its demand.

The estimated radius of influence (R_I) is actually an estimate of the radius in which measurable soil gas pressures are affected and does not always equate to gas flow. In highly permeable gravel, for example, significant gas flow can occur well beyond the measurable radius of influence. On the other hand, in a low-permeability clay a small pressure gradient may not result in significant gas flow. In this study, the assumption will be made that the R_I does equate to the area of significant gas flow; however, care must be taken in applying this assumption. During air permeability testing, an increase in O_2 concentration within the monitoring points is often an additional indicator of R_I.

In general, if the R_I is greater than the depth of the vent well, the site is probably suitable for bioventing. If the R_I is less than the vent well depth, the question of practicality arises. To scale up a bioventing project at such a site may require more closely spaced vent wells than is either economically feasible or physically possible. The decision to proceed with bioventing will be site-specific and somewhat subjective.

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5.8.1.2 Biodegradation Rate

The decision to proceed with the bioventing will be based on the results of the degradation rate calculations. From previous studies, the oxygen utilization rates that can be expected from sites contaminated with jet fuel are between 0.05 to 1.0% O_2/hour. If rates within this range are obtained and are significantly greater than background, there is sufficient evidence to assume that some microbial activity is occurring and that the addition of O_2 in these contaminated areas will enhance biodegradation. If soil gas O_2 levels are above 2 to 5% prior to any air injection, or if oxygen utilization rates are not greater than background, venting will most probably not stimulate biodegradation and consideration will be given to terminate the bioventing effort.

5.8.1.3 Regulatory Approval

Regulatory approval requirements will be defined, and if necessary, approvals will be obtained prior to initiating the bioventing test procedures. If approval is pending, a blower will be installed for startup at a later date. This will reduce costs by eliminating the need for a second visit.

5.8.1.4 U.S. Air Force Approval

Both the project officer and the base POC will be notified either verbally or in writing of the plans for initiating the bioventing test, and their approval will be required before the test is initiated. Verbal approval will be documented by the contractor.

5.8.2 Air Injection vs. Extraction Considerations

Air injection will be used as the method of choice to provide oxygen for the initial and extended pilot tests. Air injection does not result in a direct discharge of volatile organics to the atmosphere and is less expensive to operate and maintain than extraction systems. Air injection systems produce no condensate, no liquid wastes, and no contaminated air stream, and they usually do not require air permitting. Under some circumstances the use of soil gas extraction systems will need to be incorporated into the air injection system design. For example, whenever the radius of pressure influence (> 0.1" H_2O) of a vent well is close to basements or occupied surface structures, an air extraction system will be used to reduce the risk of moving gases into these areas. This precaution will prevent the accumulation of explosive or toxic vapors in these structures.

When necessary, soil gas will be extracted away from these structures and then reinjected in a unsaturated zone well on the opposite side of the extraction well. If necessary, makeup air will be added prior to reinjection to maintain oxygen levels sufficient for biodegradation (see Figure 2-3). This configuration will also have the

advantage of producing no direct discharge of volatile organics to the atmosphere, as the volatiles will be returned to the contaminated zone for treatment by the soil's active biomass.

5.8.3 Blower System Installation

On sites where initial pilot testing is successful, and the criteria in Section 5.8.1 are met, a blower system will be installed for the extended bioventing test. The blower will be configured and instrumented as shown in Figure 4-3 or 4-4. This instrumentation will ensure that important flow rate, temperature, and pressure data can be collected by base personnel during extended testing. The blower will be sized to provide a soil gas flow that is sufficient to influence all monitoring points within the contaminated zone and to provide oxygen at a rate that exceeds the highest oxygen utilization rate measured during initial testing.

Whenever possible, the blower will be sized to use the existing power source at or near the site. All electrical connections and disconnect devices will conform to local and base electrical codes. An explosion-proof blower and motor will be required for all extraction systems and in all fuel storage areas where explosion-proof equipment is mandatory. After coordination with base officials, the blower will be sited and placed in a secure and unobtrusive place. The blower will be placed in a small, portable protective shelter that is painted to conform to base color schemes. This enclosure will seldom exceed a 3-ft x 4-ft footprint and a height of 4 ft. The enclosure will protect the motor and blower from the weather and must be adequately ventilated to prevent the motor from overheating during summer months.

If necessary in high-traffic areas, piping from the vent well to the blower will be buried several inches below the surface to prevent damage. The blower system, monitoring points, and piping will be installed so as to minimize interference with existing site activities.

5.8.4 Blower Operation and Maintenance

If the site is selected for extended testing, base personnel will be required to perform a simple weekly system check to ensure that the blower is operating within its intended flow rate, pressure, and temperature range. This check must be coordinated with the base POC. Prior to departing the site, the contractor will provide a 1-hour on-site briefing for base personnel who will be responsible for blower system checks. The principle of operation will be explained, and a simple checklist and logbook will be provided for blower data. Bioventing systems are very simple, with minimal mechanical and electrical parts. Minor maintenance such as replacing filters or gauges, or draining condensate from knockout chambers, will be performed by base personnel, but they will not be expected to perform complicated repairs or analyze gas samples. Replacement

filters and gauges will be provided and shipped to the base by the contractor. Serious problems such as motor or blower failures will be corrected by the contractor.

5.8.5 Long-Term Monitoring

Most bioventing systems will require 2 or 3 years of operation to significantly reduce soil hydrocarbon levels. The progress of this system will be monitored by conducting semiannual respiration tests in the vent well and in each monitoring point, and by regularly measuring the O_2, CO_2, and hydrocarbon concentrations in the extracted soil gas and comparing them to background levels. If air injection is used, the blower can be temporarily reversed and the extracted soil gas monitored for O_2, CO_2, and hydrocarbons. Soil gas monitoring will be performed by specialized Air Force or contractor personnel on a quarterly basis. Semiannual respiration tests will be performed by the Air Force or by contractor personnel. At least twice each year, the progress of the bioventing test will be reported to the base POC.

6.0 SCHEDULE

The expected schedule for the on-site air permeability, in situ respiration, and bioventing tests is dependent on the depth to groundwater, as follows:

Case I — (Shallow Groundwater, ~20 ft or less)	Day After Initiation
— Review available data and develop plan	0-5[a]
— Air Force review	8-12
— Soil gas survey	13-15
— Install vent well/monitoring points	16-18
— Soil permeability test	19
— In situ respiration test	20-24
— Install blower and start up bioventing system	24-26
Case II — (Deep Groundwater, ~20 ft or more)	
— Review available data and develop plan	0-5[a]
— Air Force review	8-12
— Exploratory borings	13-15
— Install vent well/monitoring points	16-19
— Soil permeability test	20
— In situ respiration test	21-25
— Install blower and start up bioventing system[b,c]	26-27
Case I and II — Bioventing Test	**Month After Initiation**
— Determine regulatory requirements[b] (if any)	0
— Install and start[c] blower	1
— Conduct on-site testing	Every 6 months

(a) It will be necessary to begin the process of permitting and contracting with drillers as soon as possible after contract award, and this must be nearly complete by day 0.

(b) Regulatory requirements will need to be investigated as soon as possible after a site is identified as a potential candidate.

(c) The blower will be started only after any required regulatory approvals are received, and with the concurrence of the base POC and project officer.

These schedules are based on the assumptions that (1) no special problems will be encountered; (2) the sites will be easily accessible; and (3) useable vent well and monitoring point locations will be quickly identified. Any problems or deviations will result in a longer time frame. Deeper drilling requirements will extend the testing schedule.

7.0 REPORTING

The section describes the reports to be generated. For consistency, the following units will be used:

— English measurements for length, volume, flow, and mass, specifically:

- feet and inches for length
- gallons and ft^3 for volume
- cfh and cfm for flow
- lb for mass

— Metric units for concentrations and rates, specifically:

- mg/l for aqueous concentrations
- mg/kg for soil concentrations
- mg/(kg day) for hydrocarbon degradation

— Gaseous concentrations and O_2 utilization rates as follows:

- ppm for hydrocarbons (parts per million, i.e., $\mu l/l$, by volume)
- percent (%) for O_2, CO_2, and He (percent by volume, i.e., l x 100%/l)
- %/hr for O_2 utilization

To avoid confusion when discussing gases, the term percent (%) will refer only to concentration. Relative changes will be expressed as fractions. For example, if the O_2 concentration changes from 20% to 15%, the change will be referred to as a 5% reduction or a fractional reduction of 0.25, *not* a 25% reduction.

7.1 Test Plan

A Test Plan for each site will be prepared and submitted to the project officer and the base POC for approval. The Test Plan will consist of this generic Test Plan which provides the scope and planned activities, and a cover letter describing site-

specific applications. The Test Plan will be submitted to the project officer and base POC as early as possible before the start of the on-site test.

7.2 Monthly Reports

The contractor will provide a written monthly progress report to the project officer outlining the work accomplished for the month, the problems encountered, approaches to overcome the problems, and anticipated progress for the following month. Included in this report will be the monthly expenditure and the accumulated expenditure to date.

7.3 Verbal Communication

The contractor will be in communication with the project officer and the base POC and will report on field activities and associated problems. Oral reports will be made either to the project officer or base POC, upon demand and at least weekly to the project officer.

7.4 Site Reports

The contractor will provide a letter report (normally less than 15 pages) for each site describing the results of the soil gas permeability and in situ respiration tests as well as a description of the bioventing test initiated. This report will normally be submitted to the project officer, base POC, and others as directed by the project officer 60 days after completion of the treatability test.

8.0 RECORD OF DATA AND QUALITY ASSURANCE

A project record book will be maintained during the field tests to record events pertaining to site activities, including sampling, changes in process conditions (flow, temperature, and pressure), equipment failure, location of the test wells, calibration, and data for the respiration/air permeability tests and long-term bioventing test. The record book will be reviewed by the contractor's project manager. The project officer may review the record book upon request. Typical record sheets for the respiration and air permeability tests are shown in Figure 8-1 and 8-2, respectively. Figure 8-3 shows a typical record sheet for the long-term bioventing test.

Quality assurance will be implemented throughout the project through quality planning, quality control and quality assessment. This will include daily calibration of field analytical instrument with purchased calibration standards prior to use. Field blanks will consist of ambient air drawn through the entire sampling train set-up in an uncontaminated area of the field site. Quality assurance activities include a review of all field activities and procedures by the project manager to ensure compliance with this protocol and quality guidelines. Monthly reports to the project officer will include any significant quality assurance problems and recommended solutions.

Figure 8-1. Typical Record Sh for In Situ Respiration Test.

SITE ______________________ MONITORING POINTS ______________________

DATE ______________________ O_2 METER NO. ____________ CO_2 METER NO. ____________

LOCATION ______________________ HYDROCARBON METER NO. ______________________

SAMPLER(S) ______________________ SHUT DOWN DATE ____________ TIME ____________

Date/ Time	CO_2%	O_2%	Total Hydrocarbon	Helium	Comments	Date/ Time	CO_2%	O_2%	Total Hydrocarbon	Helium	Comments

Figure 8-2. Typical Record S. , for Air Permeability Test.

SITE ______________________ TYPE OF TEST ______________________

DATE ______________________ TEST DATE ______________________

SAMPLER(S) ______________________ TIME ______________________

Pressure/Vacuum ("H_2O)

Distance from Vent Well (ft)						Distance from Vent Well					
Time	ln(t)	MP1	MP2	MP3	MP4	Time	ln(t)	MP5	MP6	MP7	MP8

Figure 8-3. Typical Record She r Long-Term Bioventing Test.

SITE ______________________ MONITORING POINTS ______________________

DATE ______________________ O_2 METER NO. ______________ CO_2 METER NO. ______________

LOCATION ______________________ HYDROCARBON METER NO. ______________________

SAMPLER(S) ______________________ SHUT DOWN DATE ______________ TIME ______________

Date/ Time	CO_2%	O_2%	Total Hydrocarbon	Air Flow Rate (cfm)	Comments	Date/ Time	CO_2%	O_2%	Total Hydrocarbon	Air Flow Rate (cfm)	Comments

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APPENDIX

RECOMMENDED ESTIMATION METHODS FOR AIR PERMEABILITY

The U.S. Environmental Protection Agency's Risk Reduction Engineering Laboratory recently reviewed several field, laboratory, and empirical methods for determining soil gas permeability (k) and for their appropriateness in determining the feasibility of soil vapor extraction (Sellers and Fan, 1991). The conclusion of this literature review was a strong endorsement for a modified field drawdown method (Johnson et al., 1990).

The field drawdown method is based on Darcy's Law and equations for steady-state radial flow to or from a vent well. A full mathematical development of this method and supporting calculations are provided by Johnson et al. (1990). A computer program known as Hyper-Ventilate™ has been produced by Johnson for storing field data and computing k and R_I. This program will be used to speed the calculation and data presentation process. The two solution methods for k are presented below. The first solution is based on carefully measuring the dynamic response of the soil to a constant injection or extraction rate. The second solution for k is based on steady-state conditions and the measurement or estimation of R_I at steady state. The limitations and recommended application of each method are presented below. Whenever possible, field data will be collected to support both solution methods, because one or both of the solution methods may be appropriate, depending on site-specific conditions.

Dynamic Method

This test method requires that air be extracted or injected at a constant rate from a single venting well, while measuring the pressure changes at several soil gas monitoring points throughout the contaminated soil volume. The equation:

$$P' = \frac{Q}{4\pi\, m(k/\mu)} \left[-0.5772 - \ln \frac{(r_2\, e\mu)}{4k\ \text{Patm}} + \ln(t)\right] \qquad (1)$$

is used to describe the dynamic changes in soil gas pressure/vacuum where:

- P' = "gauge" pressure measured at distance r from the vent well at time t(g/cm-s^2)
- m = stratum thickness, generally the vent well screened interval (cm)
- r = radial distance from monitoring point to vent well (cm)
- k = soil gas permeability (cm^2)
- μ = viscosity of air (1.8×10^{-4} g/cm-s at 18°C)
- e = soil's air-filled void volume (dimensionless)
- t = time from the start of the test (s)
- Q = volumetric flow rate from the vent well (cm^3/s)
- Patm = ambient pressure (at sea level 1.013×10^6 g/cm-s^2)

Equation (1) predicts that the dynamic range of P'-vs.-ln(t) is a straight line with a slope of A where:

$$A = \frac{Q}{4\pi m\,(k/\mu)}$$

solving

$$k = \frac{Q\mu}{4A\pi m}$$

The HyperVentilate™ model is based on the dynamic method and a determination of the slope, A. This method of determining k requires accurate field measurements of Q at the vent well and P's-vs.-time at each monitoring point. It is most appropriately applied at sites with less permeable soils where changes in P' occur over a longer time period (10 minutes or more to monitoring point steady state). This method can be accurate for fine sandy soils where the screened interval extends to depths of over 10 ft and when monitoring points are screened at depths of 10 ft or greater. It is less accurate for sites where a high water table or shallow contamination limits the total depth of the vent well screen and monitoring points to less than 10 ft. In shallow and coarse-grained soils, vacuum or pressure levels reach steady state too rapidly to accurately plot P'-vs.-ln(t). Venting systems on shallow sandy sites are subject to higher vertical airflow which is not as accurately described by this one-dimensional radial flow equation.

Steady State-Method

This method for determining k can be used in situations where the dynamic method is appropriate. This method is based on the steady-state solution to equation (1).

$$k = \frac{Q\mu \ln(Rw/R_1)}{H\pi\, Pw\,[1 - (Patm/Pw)^2]} \qquad (2)$$

Note: Equation (2) applies only to vent wells operating under a vacuum. If air is being injected into the vent well the equation is modified as shown below:

$$k = \frac{Q\mu \ln(Rw/R_1)}{H\pi\, Patm\,[1 - (Pw/Patm)^2]} \qquad (3)$$

where Q, m, μ, and Patm have been previously defined, and

Rw = the radius of the venting well (cm)

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Air Permeability Test - Data Analysis (cont.)

① Enter radial distances of monitoring points →

② Enter measured times and gauge vacuums →

③ Enter (optional):

a) flowrate 51 (SCFM)

b) screened interval thickness 30 (ft)

r= 40 (ft)

(min)	(in H2O)
5.5	2.25
6	2.37
6.5	2.48
7	2.55
7.5	2.63
8.5	2.82
9.5	2.92

clear

k= 14.2021 darcy (A)
k= 84.6266 darcy (B)

r= 20 (ft)

(min)	(in H2O)
5.5	6
6	6.1
6.5	6.2
7	6.3
7.5	6.4
8.5	6.5
9.5	6.5

clear

k= 6.75944 darcy (A)
k= 34.6443 darcy (B)

r= 10 (ft)

(min)	(in H2O)
5.5	12.5
6	12.6
6.5	12.6
7	12.7
7.5	12.7
8.5	12.4
9.5	12.5

clear

k= 4.00444 darcy (A)
k= 15.9240 darcy (B)

—>Calculate<—

Return | Explanation & Statistics | AP8

Air Permeability Test - Data Analysis (cont.)

① Enter radial distances of monitoring points →

② Enter measured times and gauge vacuums →

③ Enter (optional):

a) flowrate 51 (SCFM)

b) screened interval thickness 30 (ft)

r= 40 (ft)

(min)	(in H2O)
.5	0.1
1	0.21
1.5	0.62
2	1.00
2.5	1.25
3	1.41
3.5	1.60
4	1.8
4.5	1.98
5	2.12

clear

k= 14.2021 darcy (A)
k= 84.6266 darcy (B)

r= 20 (ft)

(min)	(in H2O)
.5	.4
1	1.4
1.5	2.8
2	3.6
2.5	4
3	4.4
3.5	5
4	5.3
4.5	5.6
5	5.8

clear

k= 6.75944 darcy (A)
k= 34.6443 darcy (B)

r= 10 (ft)

(min)	(in H2O)
.5	1.5
1	4.5
1.5	7.5
2	9
2.5	10
3	10.7
3.5	11.2
4	11.8
4.5	12
5	12.4

clear

k= 4.00444 darcy (A)
k= 15.9240 darcy (B)

—>Calculate<—

Return | Explanation & Statistics | AP8

H = depth of screen (cm)

R_I = the maximum radius of venting influence at steady state (cm)

P_w = the absolute pressure at the venting well ($g/cm\text{-}s^2$)

The value of R_I can be determined by actually measuring the outer limit of vacuum/pressure influence under steady-state conditions, or by plotting the vacuum/pressure at each monitoring point vs. the log of its radial distance from the vent well and extrapolating the straight line to zero vacuum or pressure. An example of this solution method is included in Calculation Data Set Two below.

Sample Calculations

Data Set One

Table A-1 and Figure A-1 present the results of an air permeability test conducted at Beale AFB, CA. The soils on this site were silty with a contaminated interval (and vent well screen interval) extending from 10 to 40 ft below ground surface. Note that the plot of P'-vs.-ln(time) is a relatively straight line during the initial 10 minutes, ln (10) = 2.3, making these data good candidates for the dynamic solution method. Data from the initial 10 minutes of this test were entered into the HyperVentilate™ computer model to calculate a range of k values. An example of the input and output data for this model is provided in windows AP7 and AP8.

TABLE A-1. Air Permeability Data Set

Steady–State Flow Rate 51 SCFM

Test Time Elapsed (min)	In Time (min)	Vacuum (inches of water) at Monitoring Points (MP's) MP 1	MP 2	MP 3	MP 4	MP 5	MP 6	MP 7	MP 8	MP 9	
0.0	–	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
0.5	–	–	–	–	–	–	–	0.10	0.40	1.50	
1.0	0.00	–	–	–	–	–	–	0.21	1.40	4.50	
1.5	0.41	–	–	–	–	–	–	0.62	2.80	7.50	
2.0	0.69	–	–	–	–	–	–	1.00	3.60	9.00	
2.5	0.92	–	–	–	–	–	–	1.25	4.00	10.00	
3.0	1.10	–	–	–	–	–	–	1.41	4.40	10.70	
3.5	1.25	–	–	–	–	–	–	1.60	5.00	11.20	
4.0	1.39	–	–	–	–	–	–	1.80	5.30	11.80	
4.5	1.50	–	–	–	–	–	–	1.98	5.60	12.00	
5.0	1.61	–	–	–	–	–	–	2.12	5.80	12.40	
5.5	1.70	–	–	–	–	–	–	2.25	6.00	12.50	
6.0	1.79	–	–	–	–	–	–	2.37	6.10	12.60	
6.5	1.87	–	–	–	–	–	–	2.48	6.20	12.60	
7.0	1.95	–	–	–	–	–	–	2.55	6.30	12.70	
7.5	2.01	–	–	–	–	–	–	2.63	6.40	12.70	
8.5	2.14	–	–	–	–	–	–	2.82	6.50	12.40	
9.5	2.25	–	–	–	–	–	–	2.92	6.50	12.50	
10.5	2.35	–	–	–	–	–	–	2.96	6.50	12.50	
14.0	2.64	–	–	–	–	–	–	3.00	6.50	12.40	
19.0	2.94	–	–	–	–	–	–	3.05	6.40	11.90	
24.0	3.18	–	–	–	–	–	–	3.10	6.20	11.00	
29.0	3.37	–	–	–	–	–	–	3.37	6.00	10.40	
34.0	3.53	–	–	–	–	–	–	3.40	5.80	9.90	
39.0	3.66	–	0.8	0.4	0.7	2.2	1.7	3.40	–	–	
44.0	3.78	0.3	–	–	–	–	–	–	–	–	
								40	20	10	<--- Distance from VE - 2
		27.5–29.5	18–20	13–15	14–16	38–40	30–32	38–40	38–40	38–40	<--- Screen interval depth

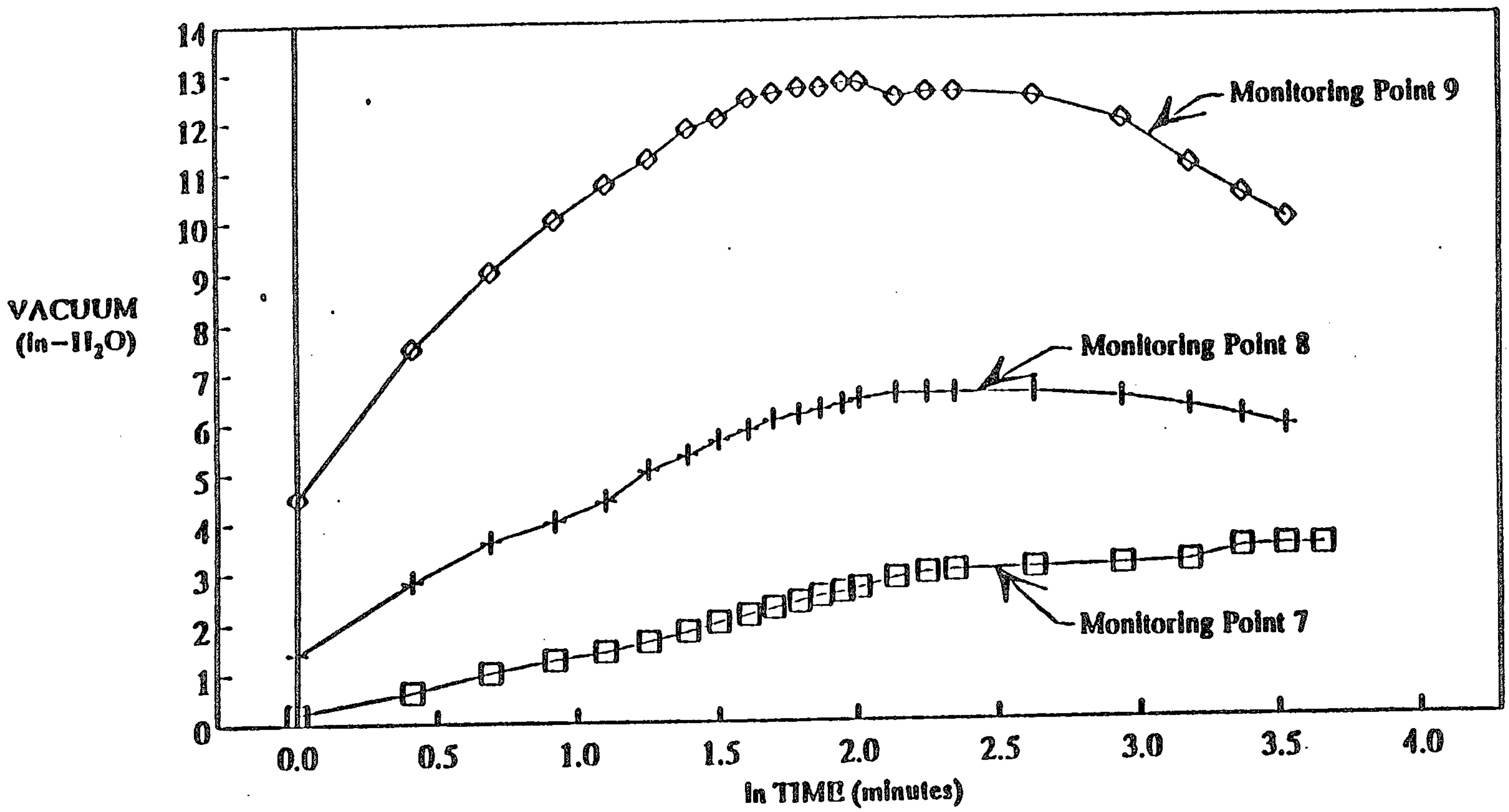


Figure A-1. Vacuum vs. ln Time, Test 2, Bioventing Pilot Test, Site 22-A20, Beale AFB, California

TABLE A-2. Field Test Data for Soil Determination of Soil Permeability at a Gasoline-Contaminated Site

Time (min)	Air Flow (cfm)	Vacuum (inches of water) measured at various monitoring points										
		Unit	Well	F	E	G	D	H	C	I	B	A
0.0	0	0	2	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.5	30	109	80	1.90	0.90	0.25	0.15	0.00	0.00	0.00	0.00	0.00
1.5	30	109	80	1.90	0.90	0.30	0.20	0.05	0.00	0.00	0.00	0.00
5.0	30	109	80	1.90	0.90	0.30	0.20	0.05	0.00	0.00	0.00	0.00
10.0	30	109	80	1.90	0.95	0.30	0.20	0.05	0.00	0.00	0.00	0.00
15.0	30	109	80	1.90	0.95	0.30	0.20	0.05	0.00	0.00	0.00	0.00
20.0	30	109	80	1.90	0.95	0.30	0.20	0.05	0.00	0.00	0.00	0.00
		Distance from well (ft)		3	6	9	12	15	18	21	24	27

$Rw = 2.54$ cm

$H = 60.96$ cm

$Q = 14,158\ cm^3/sec$

$\mu = 1.8 \times 10^{-4}$ g/cm-s

$Patm = 8.14 \times 10^5\ Dynes/cm^2$

Computer window AP7 provides a summary of two mathematical solutions for air permeability (k) using the dynamic method. Window AP8 is the example data entry and solution sheet. The calculated range of k values for this test is shown at the bottom of window AP8. Permeability values of 4 to 14 darcy are based on Equation 1 in window AP7 and provide the most accurate estimate, because both the extraction rate (Q) and the screened interval (m) were known for this test. The more conservative range of 4 to 14 darcy will be used for full-scale design. These air permeability values are approximately one order of magnitude higher than would be expected for silty soils. The presence of 10 to 15% sand (by weight) in this soil has increased the average permeability at this site.

Data Set Two

Table A-2 and Figure A-2 are the results from a test conducted in a silty loam with a contaminated interval of only 5.2 ft and a screened interval from 2.7 to 5.2 ft below ground surface. Note that the almost immediate steady state reached at this site does not produce the P′-vs.-ln(time) plot required for the dynamic solution method. In this case the steady-state solution offers the only approximation of k and R_I.

$$k = \frac{Q\mu \ln(Rw/R_I)}{H\pi \, Pw \, [1 - (Patm/Pw)^2]}$$

For this test:

$$Q = 1.4 \times 10^4 \text{ cm}^3/\text{s}$$

$$H = 2 \text{ ft } (61 \text{ cm})$$

$$\mu = 1.8 \times 10^{-4} \text{ g/cm-s}$$

$$Pw = 80"H_2O \text{ vacuum} \times 3.61 \times \frac{10^{-2} \text{ psia}}{"H_2O} = 2.88 \text{ psia}$$

$$Pw \text{ absolute} = 14.7 \text{ psia} - 2.88 \text{ psia} = 11.82 \text{ psia}$$

$$11.82 \text{ psia} \times 6.9 \times \frac{10^4 \text{g/cm-s}^2}{\text{psia}} = 8.16 \times 10^5 \text{g/cm-s}^2$$

$$Patm = 1.01 \times 10^6 \text{g/cm-s}^2$$

$$Rw = 1 \text{ in.} = 2.54 \text{ cm}$$

R_I = ~15 ft (457 cm) based on all monitoring points reported in Table A-2

$$k = \frac{(1.4 \times 10^{4} cm^{3}/s)(1.8 \times 10^{-4} g/cm\text{-}s)\ln(2.54/457)}{(61\ cm)(3.14)(8.16 \times 10^{5} g/cm\text{-}s)(1 - [1.01/0.816]^{2})}$$

$k = 1.6 \times 10^{-7}\ cm^2$ or 0.16 darcy, which is typical for silty soils.

References

Johnson, P.C., M.W. Kemblowski, and J.D. Colthart. 1990. "Quantitative Analysis for the Cleanup of Hydrocarbon-Contaminated Soils by In-Situ Soil Venting," *Ground Water* 28(3), May-June.

Sellers, K., and C.Y. Fan. 1991. "Soil Vapor Extraction: Air Permeability Testing and Estimation Methods." In: *Proceedings of the 17th RREL Hazardous Waste Research Symposium*, EPA/600/991/002, April.

KANXTEST.WKQ

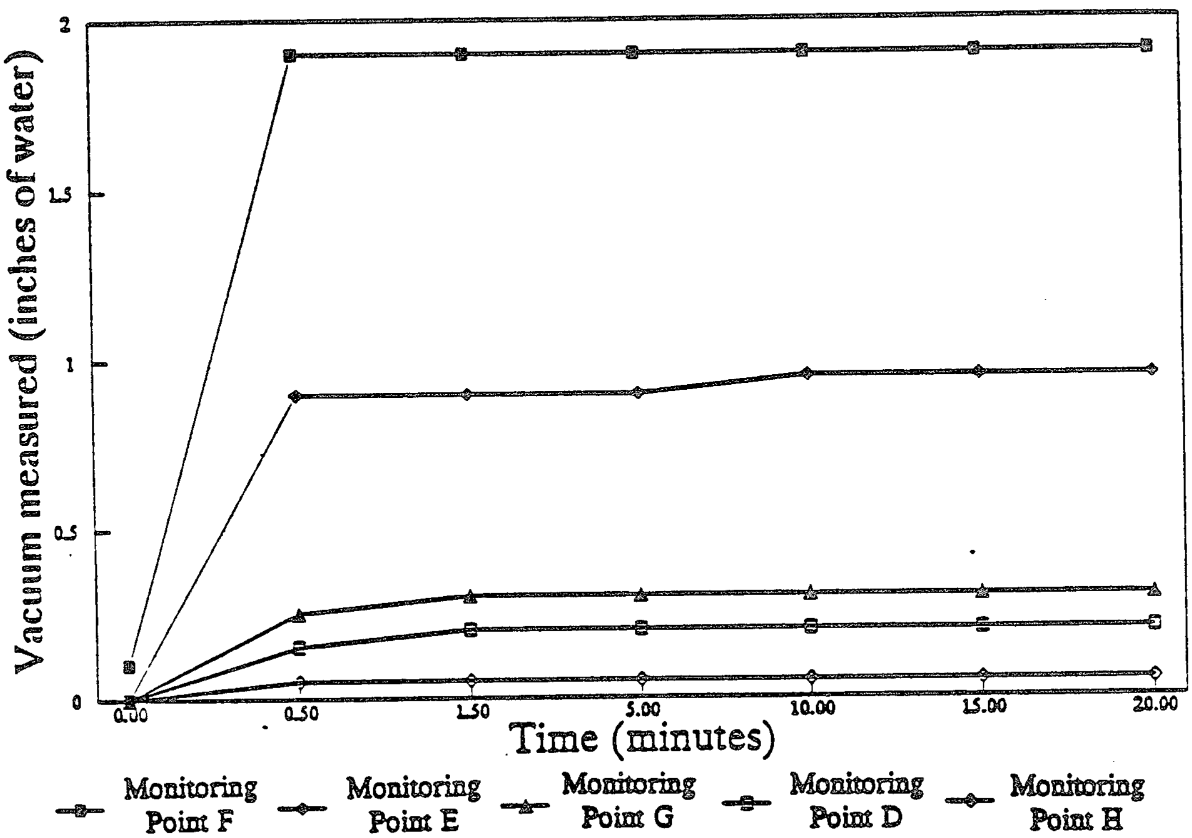


Figure A-2. Results of a Field Test to Determine Soil Permeability to Airflow, k, September 16, 1991

TABLE A-2. Field Test Data for Soil Determination of Soil Permeability at a Gasoline-Contaminated Site

Time (min)	Air Flow (cfm)	Vacuum (inches of water) measured at various monitoring points										
		Unit	Well	F	E	G	D	H	C	I	B	A
0.0	0	0	2	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.5	30	109	80	1.90	0.90	0.25	0.15	0.00	0.00	0.00	0.00	0.00
1.5	30	109	80	1.90	0.90	0.30	0.20	0.05	0.00	0.00	0.00	0.00
5.0	30	109	80	1.90	0.90	0.30	0.20	0.05	0.00	0.00	0.00	0.00
10.0	30	109	80	1.90	0.95	0.30	0.20	0.05	0.00	0.00	0.00	0.00
15.0	30	109	80	1.90	0.95	0.30	0.20	0.05	0.00	0.00	0.00	0.00
20.0	30	109	80	1.90	0.95	0.30	0.20	0.05	0.00	0.00	0.00	0.00
		Distance from well (ft)		3	6	9	12	15	18	21	24	27

$Rw = 2.54$ cm

$H = 60.96$ cm

$Q = 14{,}158\ cm^3/sec$

$\mu = 1.8 \times 10^{-4}$ g/cm-s

$Patm = 8.14 \times 10^{5}$ Dynes/cm^2

Note: Locations of the extraction well and monitoring points (A through I) are shown in Figure A-1.

ES ADDENDUM TO PROTOCOL DOCUMENT

INSERT 1. p. 27 Add to criteria 4

At sites that will have underground piping between the blower and vent well, the upper 18-inches of annular space will be left open to allow access for below-grade well head completion.

INSERT 2. p 31 Replace first three paragraphs

Monitoring point construction will vary depending on the depth of drilling, drilling technique, and soil and hydrologic conditions. Basically, the monitoring points will consist of rigid, 1/4-inch inside diameter, Schedule 80 PVC pipe to the specified depth with a 6-inch length of 1-inch diameter Schedule 40 PVC well screen with 0.020-inch slots. Each monitoring point screen will be centered within a 1 to 2 foot thick sand pack consisting of clean, rounded silica sand with a 6-9 sieve grain size. In low permeability soils, a slightly longer sand pack may be desirable. In wet soils, and where the depth to the groundwater surface fluctuates greatly, a longer sand pack with the screen near the top may be desirable. An approximately 1-foot thick sand pack will also be placed directly below the well box to provide drainage.

The annular space between sand packs will be filled with bentonite to form air-tight seals between sampling intervals. The bentonite seals will be hydrated in place instead of using bentonite slurry to assure long-term integrity of the seals. Bentonite slurry emplaced in monitoring points constructed in dry and/or sandy soils may dehydrate and shrink with time, resulting in the loss of the seal and settling or collapse of the overlying sand pack. The 2 feet of bentonite immediately above and below the annular sand pack intervals will consist of 1/4-inch diameter sodium bentonite pellets or granular bentonite less than 1/4-inch in diameter. These 2-foot thick intervals will be placed in 6-inch layers and each layer hydrated with potable water before placement of subsequent layers. To assure adequate hydration of each 6-inch bentonite layer, the water will be added in 2 or 3 portions with sufficient time allowed between additions to allow for hydration. The bentonite is sufficiently hydrated when the water will no longer penetrate the seal. Backfill between bentonite seals will consist of bentonite chips (hole plug) hydrated in place with potable water.

PVC pipe will be used to collect soil gas for CO_2 and O_2 analysis in the 0.25% range, and for JP-4 hydrocarbons in the 100 ppm range or higher. The pipe material must have sufficient strength and be nonreactive. Sorption and gas interaction with the pipe materials have not been significant problems for this application. If a monitoring point will be used to monitor specific organics in the low ppm or ppb range, Teflon® or stainless steel may be necessary. However, this will not normally be the case.

The top of each ¼ inch PVC pipe will be finished with a ¼ inch ball valve fitted with a 3/16 inch hose barb. Each screened depth will be labeled using aluminum tags with a name as follows:

INSERT 3. p. 33, Section 4.2.4 Replace 3rd sentence

Type K (chromel-Alumel) thermocouples with Type K mini connectors will be used.

INSERT 4. p. 33 Replace Section 4.3

4.3 Background Monitoring Point

In addition to the vent well and the monitoring points installed in contaminated soils, a background monitoring point will be installed in uncontaminated soil to monitor the background respiration of natural organic matter. Soil gas in uncontaminated soil generally has O_2 levels between 15 and 20% and CO_2 levels between 1 and 5%. The background monitoring point will be similar in construction to the monitoring points installed in contaminated soils (Figure 4-2) and screened at similar depths in the same stratigraphic formation.

Alternatively, an existing groundwater monitoring well can be used as a background monitoring point if the well is installed in clean soils and the well screen extends several feet above the groundwater surface.

INSERT 5. p. 37 following 1st paragraph

WELL PURGING PROCEDURES

Prior to performing the following measurements and collecting soil gas samples, the vent well and monitoring point volumes must be purged. The purge volume should be approximately three times the vent well or monitoring point volume. Required purge volumes vary with length of sand pack, bore hole diameter and soil type. To determine adequate purging times for each sampling point, oxygen concentrations will be monitored during the initial purging until the concentrations reach a minimum value. Figure 5-1 shows a typical setup for the initial purging. For the vent well, this will depend on depth. For monitoring points and soil gas probes, this purging typically takes less than one minute using a one cubic foot per minute (cfm) pump. The required purge time will be recorded in the field book and used for all subsequent purging to ensure consistent measurements. Especially in fine-grained soils, it is important to avoid over-purging, which can draw in fresh, oxygenated air and result in erroneous measurements. Samples and measurements should be taken immediately upon completion of purging. NOTE: FOR ANYTHING OTHER THAN SANDY SOILS THE SAMPLE MUST BE COLLECTED USING THE VACUUM CHAMBER (EGG).

INSERT 6. p. 44 Replace title of Section 5.5

5.5 COLLECTION OF SOIL AND SOIL GAS SAMPLES

INSERT 7. p. 45 following 2nd paragraph

In addition to the listed soil analyses, two soil analyses will be performed to evaluate benzene toluene, ethylbenzene, and xylene (BTEX) and total recoverable petroleum hydrocarbons (TRPH) and three soil gas analyses will be performed to evaluate BTEX and total volatile hydrocarbon (TVH).

SOIL

For each additional soil sample to be analyzed for BTEX and TRPH, one 2" diameter by 6" length thin walled, brass tube taken from a split spoon sampler, will be provided. These samples must be preserved by shipping at 4°C.

SOIL GAS

For each soil gas analyses, one SUMMA® canister will be provided. This is not to be chilled or preserved for shipping.

INSERT 8. p. 48, Section 5.7.1, 1st paragraph, last sentence Figure 2-9 should read 5-2.

INSERT 9. p. 48, Section 5.7.1 following 1st paragraph.

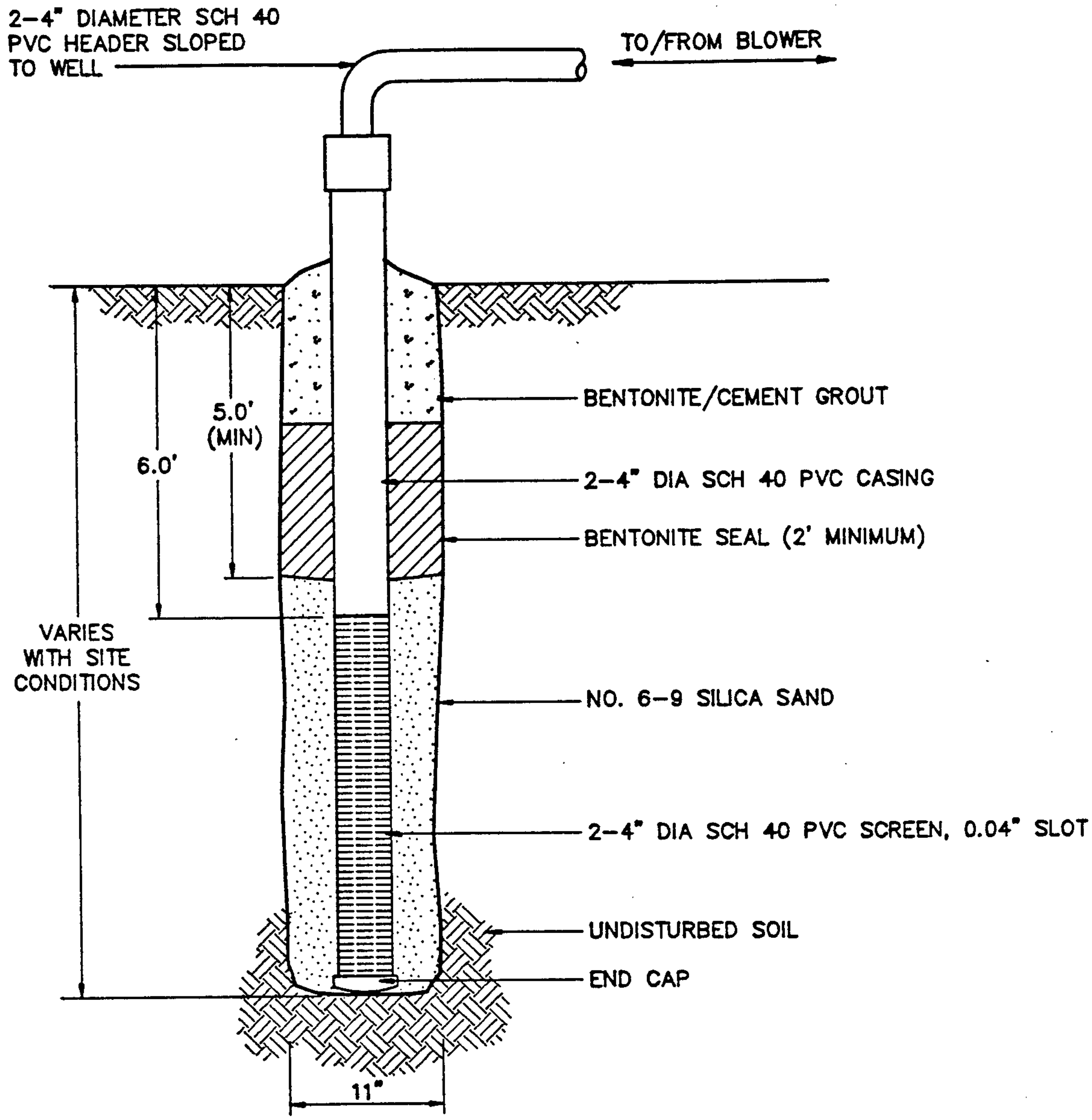
HELIUM INJECTION

The key to successful helium diffusion testing is to provide a uniform injection concentration of helium. This requires regular checks on helium injection concentrations at the well head and may require adjustment of the two-stage regulator controlling helium and air injection to the monitoring point. A helium mixing device provided by ES-Denver will be used to inject a constant helium concentration into multiple wells.

INSERT 10. p. 53, Section 5.7.2, replaces 2nd paragraph.

Battelle and AFCEE have determined that helium loss cannot be quantitatively related to oxygen diffusion. Helium will be used as a conservative tracer to detect serious leakage or short-circuiting in each monitoring point used for respiration testing. If a monitoring point loses over 75% of its initial helium concentration in the first 1000 minutes of respiration testing, that monitoring point will be considered unacceptable for respiration testing.

INSERT 11. p. 29 Replace Figure 4-1 with the following figure.



NOT TO SCALE

FIGURE 4-1

TYPICAL
INJECTION/VACUUM VENTING
WELL CONSTRUCTION DETAIL

ENGINEERING-SCIENCE, INC.
Denver, Colorado

93DN0199, 01/20/93 at 14:59

INSERT 12. p. 33 Replace Figure 4-2 with the following figure.

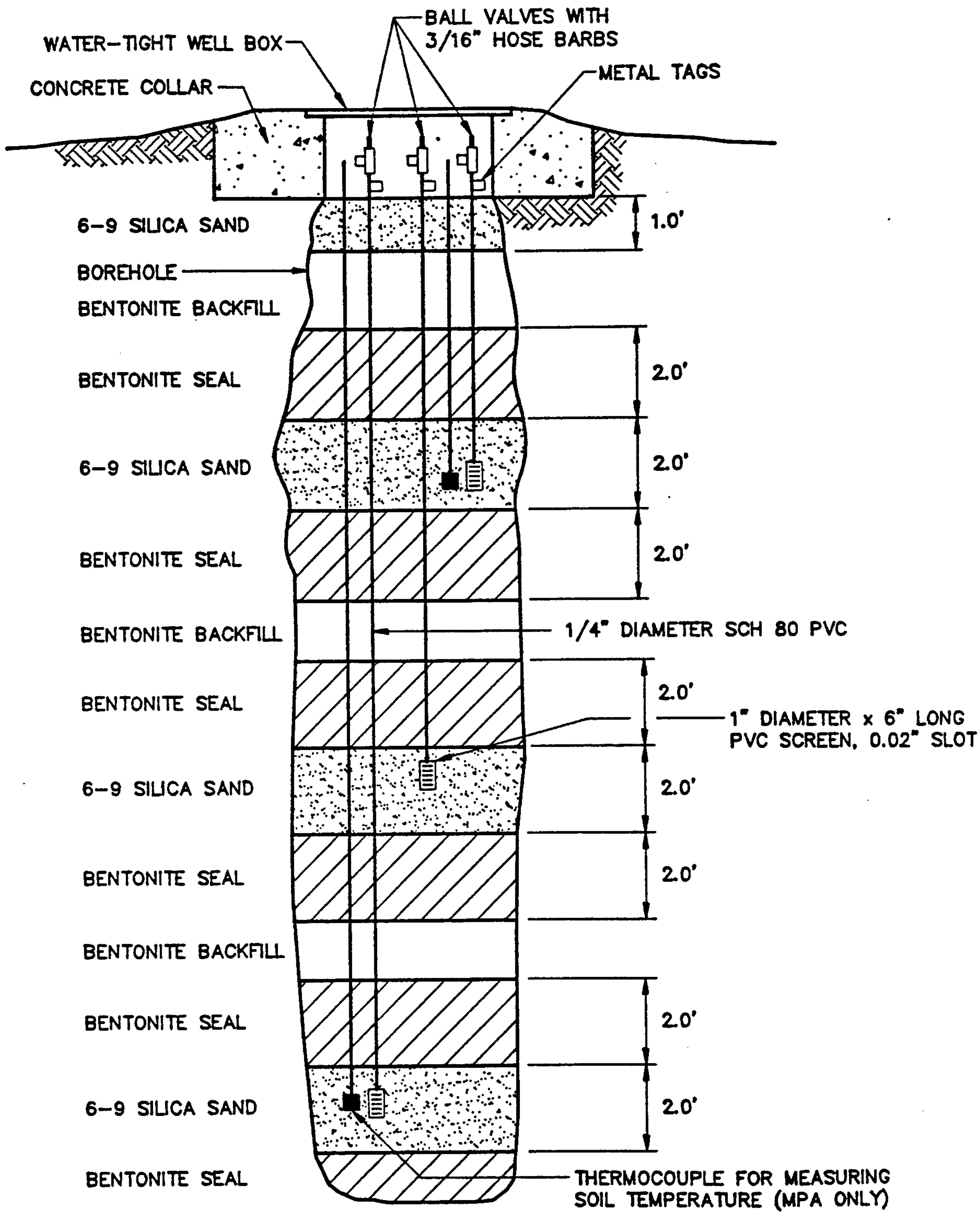


FIGURE 4-2

TYPICAL MONITORING POINT
CONSTRUCTION DETAIL

ENGINEERING-SCIENCE, INC.
Denver, Colorado

ES

93DN0164, 01/21/93 at 12:51

INSERT 13. p. 48 Insert the following figure.

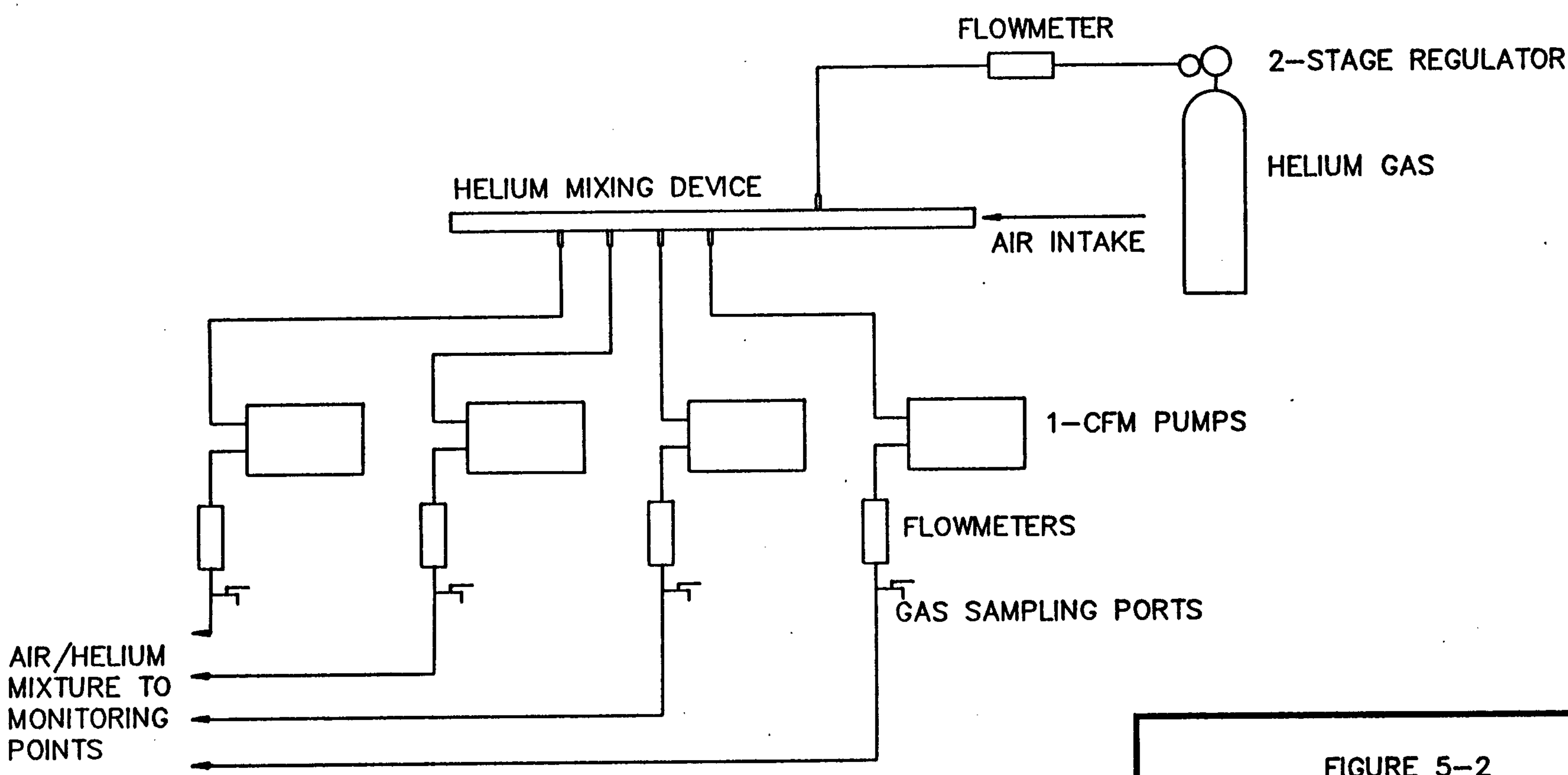


FIGURE 5-2

TYPICAL AIR/HELIUM INJECTION APPARATUS FOR IN-SITU RESPIRATOR TESTS

ENGINEERING-SCIENCE, INC.
Denver, Colorado

93DN0209, 01/25/93 at 14:23

PILOT TEST OUTLINE

AND

EQUIPMENT LIST

BIOVENTING PILOT TEST OUTLINE

1 PRE MOBILIZATION

- ELECTRICAL POWER READY?
- Air, drilling and other permits
- Work/Health and Safety Plans approved by base/regulators?
- Utilities cleared?
- Arrange to meet with electrician upon arriving on site
- Check supplies
- Hotel, airline, and vehicle rental reservations
- Security clearance information (ES and driller personnel)
- Potential background well information: existing groundwater monitoring well and/or location for new monitoring point outside contaminated area

2 DRILLING/SOIL SAMPLING

2.1 Pre-Drilling

- Meet with base contact
- Check utility clearance
- Soil gas survey: confirm low O_2 concentrations
- Locate water source
- Arrange for drum staging
- Establish decontamination area
- Drum labeling instructions/materials from base contact

2.2 Drilling

- Soil sampling: see Sampling Plan
- Collect one soil sample from VW, MPA, and MPB

2.3 MP Construction

- Install 2 thermocouples in MPA. Compare with mercury thermometer before installing

3 BASELINE MEASUREMENTS

- Purge MPs, VW; determine optimum purge times; check vacuum to determine if "egg" is needed for sampling
- Measure O_2, CO_2, and hydrocarbon concentrations
- Collect SUMMA air samples; MPA, MPC, VW
- Measure soil temperature

4. PERMEABILITY TEST

4.1 System Check

- Set-up, zero gages
- Measure initial pressures
- Check flow rate, injection pressure, pressure response at MPs
- Choose appropriate pressure gages

4.2 Permeability Test

- Run blower until steady state for pressure achieved and O_2 response measured at all/most MPs
- Measure post-test O_2, CO_2, and HC concentrations
- Measure soil temperature
- Begin respiration test for the VW

5. RESPIRATION TEST

- Continue measuring O_2, CO_2 and HC at VW
- Choose 3 or 4 MPs with low initial O_2 and high initial HC concentrations. Use MPs where soil samples collected.
- Inject helium/air mixture (2-5% Helium) using helium mixing manifold
- Inject air at background MP/well if initial O_2 concentration is less than 18 percent
- Inject air for 20 hours
- Measure flow rates and Helium concentrations during injection
- After injecting for 20 hours, begin measuring O_2, CO_2 HC, and helium concentrations
- Measure soil temperature

6. EXTENDED PILOT TEST BLOWER SYSTEM

- Set-up system
- Paint blower enclosure appropriate color to match nearby buildings; Check with base contact for proper color selection
- Measure O_2 concentrations at MPs
- Start blower and adjust air flow to VW. reduce air flow if short circuiting is occurring or strong fuel odor is noticed
- Check injection pressure, temperature, motor amps/voltage
- Set automatic pressure relief valve at or below maximum blower rating
- Set starter overload protection to 0.85 X amperage on motor nameplate (FLA) for single phase power
- If motor amperage too high, adjust manual bleed valve
- Run blower for approximately 24 hours and until O_2 change and pressure response is measured in all/most MPs
- Check injection pressure, temperature, relief valve setting (should not continuously release air), and motor amps. Make any necessary adjustments
- Train base personnel on system monitoring and maintenance
- Provide base with O&M manual (fill in the blanks !!), data sheets, and 2 spare filter elements (oil, grease, etc. for PD blowers)
- Leave key for blower enclosure with base contact

7. DEMOBILIZATION

- General site check
- Arrangement with base for disposal soil cuttings, decontamination water, etc.?
- Secure items in trailer; check trailer lights, brakes, tires, etc.

BIOVENTING PILOT TEST EQUIPMENT LIST

ITEM	NEEDED	NOT NEEDED	IN STOCK	ADD TO STOCK
SOIL GAS SURVEY				
Jack				
Hammer				
Probe set				
Spare screens				
Tygon tubing, 1/8"				
Probe tips				
Probe tip screens				
DRILLING, SOIL SAMPLING, AND AIR SAMPLING				
Alconox				
Baggies				
Boring logs				
Brass liners				
Brushes				
Caps, plastic				
Chain-of-Custody forms				
Decon buckets				
DI water				
Field books				
Garbage bags				
Haz Waste labels				
Keys				
Labels				
Locks				
Pin flags				
Sample jars				
Sampling Plan				
SUMMA canisters and adaptor				
Teflon squares				
Trowels				
Work plans & reports				
MONITORING POINT & VENT WELL CONSTRUCTION				
Aluminum tags				
Hose barbs				
MP Flush-mount covers, 8"				
MP Screen assemblies				
MP Tops				
Hose barbs, 1/4" NPT x 3/16"				
1/4" ball valve				
Threaded adaptor				
Thermocouples				
VW Flush-mount covers, 12"				
METERS ETC.				
Calibration gas				
O2/CO2 (5% CO2, 95% nitrogen)				
Helium				
Hexane (4400 ppm)				
Digital thermometer (for thermocouples)				
O2/CO2 meter				
Block-type flow meters				
0-3 SCFH (helium injection)				
0-100 SCFH (1 CFM sampling/injection pumps)				
0-40 CFM (measure bleed air)				
Helium detector				
TVH analyzer				
2-Stage regulator (for helium)				
1-stage regulator (for calibration gas)				

ITEM	NEEDED	NOT NEEDED	IN STOCK	ADD TO STOCK

AIR PERMEABILITY TEST

Data sheets				
Magnehelic pressure gages				
0–1"				
0–5"				
0–10"				
0–20"				
0–50"				
0–100"				
0–150"				
Pilot test P.D. blower				
Air flow measurement				
Pitot tube				
Tubing				
0–0.25" gage				
0–0.50" gage				
2"–diameter x 5'long PVC				
4"–diameter x 8' long PVC				
Flexible connectors (Fernco)				
1 1/2" x 2"				
1 1/2" x 4"				
2" x 2"				
2" x 4"				
4" Street ell				
2" Street ell				

RESPIRATION TEST

Data sheets				
Helium mixing manifold				
Meters				
Portable pumps (1 CFM)				
Portable pump covers				
Tubing, 3/16"				
Tees				
Clamps				
VW top with 3/16" hose barb				
Regulator, helium				

EXTENDED TEST BLOWER SYSTEM

Air filters				
Air filter elements (spare)				
Blower (and alternate ?)				
Blower enclosure				
Bleed valve (gate valve)				
Misc. pipe fittings				
1 1/2" for regenerative blower				
3/4" for rotary vane blower				
Pressure gage (dial)				
Pressure relief valve (automatic)				
PVC and/or iron pipe fittings				
VW top				
Blower to VW				
Gages, dial type (vacuum & pressure)				
Starter (and alternate ?)				
Thermometer (dial)				

ITEM	NEEDED	NOT NEEDED	IN STOCK	ADD TO STOCK

HEALTH AND SAFETY

Calibration gas				
Draeger kit				
Explosimeter				
Eye wash				
First Aid Kit				
Gloves–inner				
Gloves–outer				
Gloves–leather				
Goggles/safety glasses				
Heath & safety plan				
Hard hats				
Hnu/TIP/TVHA				
Nuke boots				
Steel toe boots				
Rain gear				
Tyvek suits				

MISCELLANEOUS

Camera				
Extension cords				
Federal Express Forms				
Field Clipboard				
Film				
Flagging tape				
Generator				
Helium				
Light, clamp–on				
List of contacts				
Locks				
Paper towels				
Pens and Markers				
Pick axe				
Scissors				
Shovel				
SUMMA Canister adaptor				
Tape–Duct				
Tape–Clear				
Tool kit				

APPENDIX B

PHOTODOCUMENTATION OF EXISTING CONDITIONS AT SITE

ENGINEERING-SCIENCE PHOTOGRAPHY LOG SHEET

CLIENT AFCEE, Ord 2, Mod 2 **JOB NO.** NC289

DATE: *3/12/93*

TIME: *1355*

DESCRIPTION:

Stockpiled soils looking southeast from the proposed concrete treatment pad.

PHOTOGRAPHED BY: *MBP*

DATE: *3/12/93*

TIME: *1404*

DESCRIPTION:

Proposed concrete treatment pad looking south.

PHOTOGRAPHED BY: *MBP*

ENGINEERING-SCIENCE PHOTOGRAPHY LOG SHEET

CLIENT AFCEE, Ord 2, Mod 2 **JOB NO.** NC289 **Sheet 2 of 2**

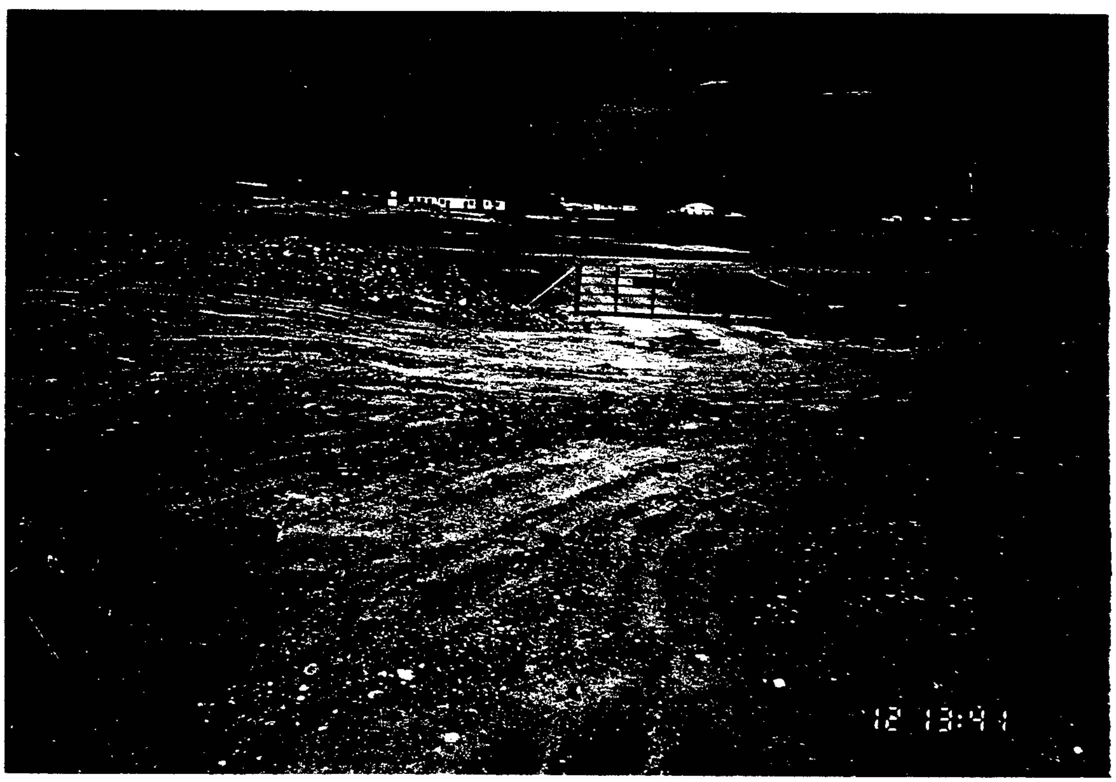
DATE: *3/12/93*

TIME: *1332*

DESCRIPTION:

Stockpiled soils.

PHOTOGRAPHED BY: *MBP*



DATE: *3/12/93*

TIME: *1341*

DESCRIPTION:

Looking north from the stockpiled soils toward gate. Covered stockpiled soils in northwest and northeast background are Law Environmental soil piles.

PHOTOGRAPHED BY: *MBP*

APPENDIX C

QAPP

QUALITY ASSURANCE PROJECT PLAN

Prepared for

BEALE AIR FORCE BASE

April 1993

Prepared by

ENGINEERING-SCIENCE, INC.
PLANNING • DESIGN • CONSTRUCTION MANAGEMENT
1301 MARINA VILLAGE PARKWAY, ALAMEDA, CA 94501 • 510/769-0100
OFFICES IN PRINCIPAL CITIES
35-29

QUALITY ASSURANCE PROJECT PLAN

Prepared for

BEALE AIR FORCE BASE

April 1993

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OFFICES IN PRINCIPAL CITIES
35-29

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF FIGURES

LIST OF TABLES

QUALITY ASSURANCE PROJECT PLAN

1.0 PROJECT DESCRIPTION

1.1 Project Location

Beale Air Force Base is located in Yuba County approximately 10 miles east of Marysville, California (Figure 1). The base is approximately 40 miles north of Sacramento and 130 miles northeast of San Francisco, California.

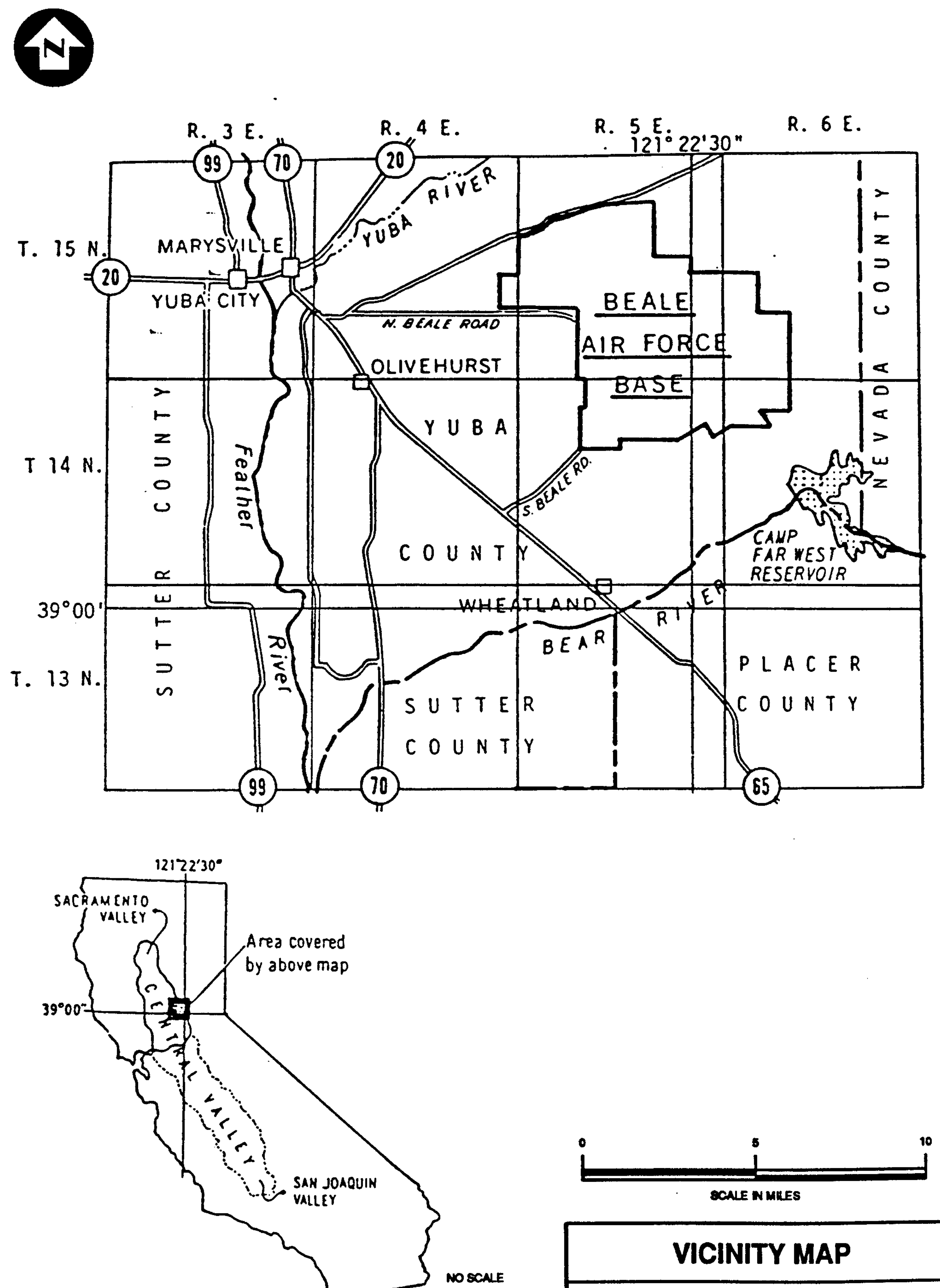
The treatability study and soil stockpile work will take place in an area known as the Contaminated Soil Treatment Area (Figure 2). The area is relatively flat with open grass covered fields with concrete and asphalt pads.

1.2 Project Description

The Beale Air Force Base Surface Bioventing Treatability Study and Site 22 Project are part of the Air Force Installation Restoration Program (IRP). The objective of the IRP is to assess past hazardous waste disposal and spill sites on Air Force installations and develop remedial actions consistent with the National Contingency Plan (NCP) for those sites which pose a threat to human health and welfare or the environment. This objective is achieved through a staged Remedial Investigation/Feasibility Study (RI/FS) process in which conclusions and recommendations drawn from accurate and validated data are used to structure and guide subsequent activities.

At any point during the RI/FS process, corrective measures may be instituted when a threat to health or the environment is detected during an IRP field investigation which requires expedited action. These corrective measures are part of the RI/FS process and occur before any formal decision documents or records of decision are signed.

FIGURE 1



SOURCE: GROUNDWATER CONDITIONS AT BEALE AIR FORCE BASE AND VICINITY, CALIFORNIA. U.S. GEOLOGICAL SURVEY OPEN-FILE REPORT 80-204, PAGE, 1980

VICINITY MAP

BEALE AIR FORCE BASE
CALIFORNIA

REV. 1 C251-01.DWG 03/08/93

ENGINEERING-SCIENCE, INC.

Figure 2 Location of UST Exploration Areas

In December of 1988, the Commission on Base Realignment and Closure recommended the relocation of its 323rd Flying Training Wing - the Specialized Undergraduate Navigation Training (SUNT) - currently operating out of Mather Air Force Base (AFB) to nearby Beale AFB. As part of the SUNT relocation to Beale AFB, the USAF determined that underground storage tanks (USTs) be located and removed from the vicinity of the proposed SUNT campus. The tank removal program is an expedited action in the IRP program. ES was retained to remove USTs in the area of the proposed SUNT campus. Following removal of the USTs, the scope of work was modified to include performing an air permeability and *in situ* respiration test at former tank site 22-A20 (west of Building 2171), installing an *in situ* bioventing system, and conducting a surface bioventing treatability study on stockpiled soils contaminated with hydrocarbons.

1.3 Scope of Work

The modified delivery Order (Order 02/Modification 02) includes: 1) the completion of a treatability study for a surface bioventing system to treat TPH contaminated soil; and 2) one year of operation and maintenance of the *in situ* bioventing system at UST Site 22-A20 adjacent to Building 2171.

Soil treatability study at a pad at the base adjacent to the TPH soil holding area and completion of the operation/reporting on the Site 22-A20 Bioventing project. The project scope elements over a one-year period include:

- Project Management (PM)/Confirmation notices
- Meetings
- Monthly R&D reports
- Treatability Study Workplan
- Health and Safety Plan (HASP)
- Quality Assurance Project Plan (QAPP)
- Bid Document
- Pilot test on 150 cubic yards of contaminated soil
- Surface bioventing treatability report
- Treatability study guidance manual
- Equipment installation

- *In situ* respiration test
- Quarterly letter reports
- Training of base personnel for Site 22-A20
- Operation and maintenance for Site 22-A20
- *In situ* respiration test for Site 22-A20
- Quarterly letter reports for Site 22-A20

The Modification 2 to Order 2 Statement of Work from the Air Force Center for Environmental Excellence is contained in Appendix A.

2.0 QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENT DATA

The overall quality assurance (QA) objective for the Beale Air Force Base project is to develop and implement procedures for data collection activities that will provide for data of known and documented quality, and which will be legally defensible should that need arise. Field and laboratory QA and quality control (QC) requirements defined in U.S. EPA guidelines are designed to ensure that acceptable levels of data quality are maintained throughout the sampling and analysis program. These requirements are detailed in EPA SW-846, 3rd Edition.

If the analytical data fail to meet the QC objectives described and corrective measures have been taken, ES's Informal Technical Information Report (ITIR) will include a discussion of why the data failed to meet the objectives and a description of the limitations and usefulness of the data.

The following corrective actions may be taken for the data that do not meet QA objectives: (1) a verification that the analytical measurement system was in control, (2) a thorough check of all calculations, (3) use of data qualifier (flags), or (4) reanalysis of the affected samples.

The quality assurance objectives for all measurement data include considerations of accuracy, precision, completeness, representativeness, and comparability as described below. Figure 3 shows the Data Reduction, Validation and Reporting Scheme. Goals for accuracy and precision for laboratory analyses are presented in Table 1. Analytical procedures and detection limits, and laboratory quality control checks are discussed in Sections 6.0 and 8.0.

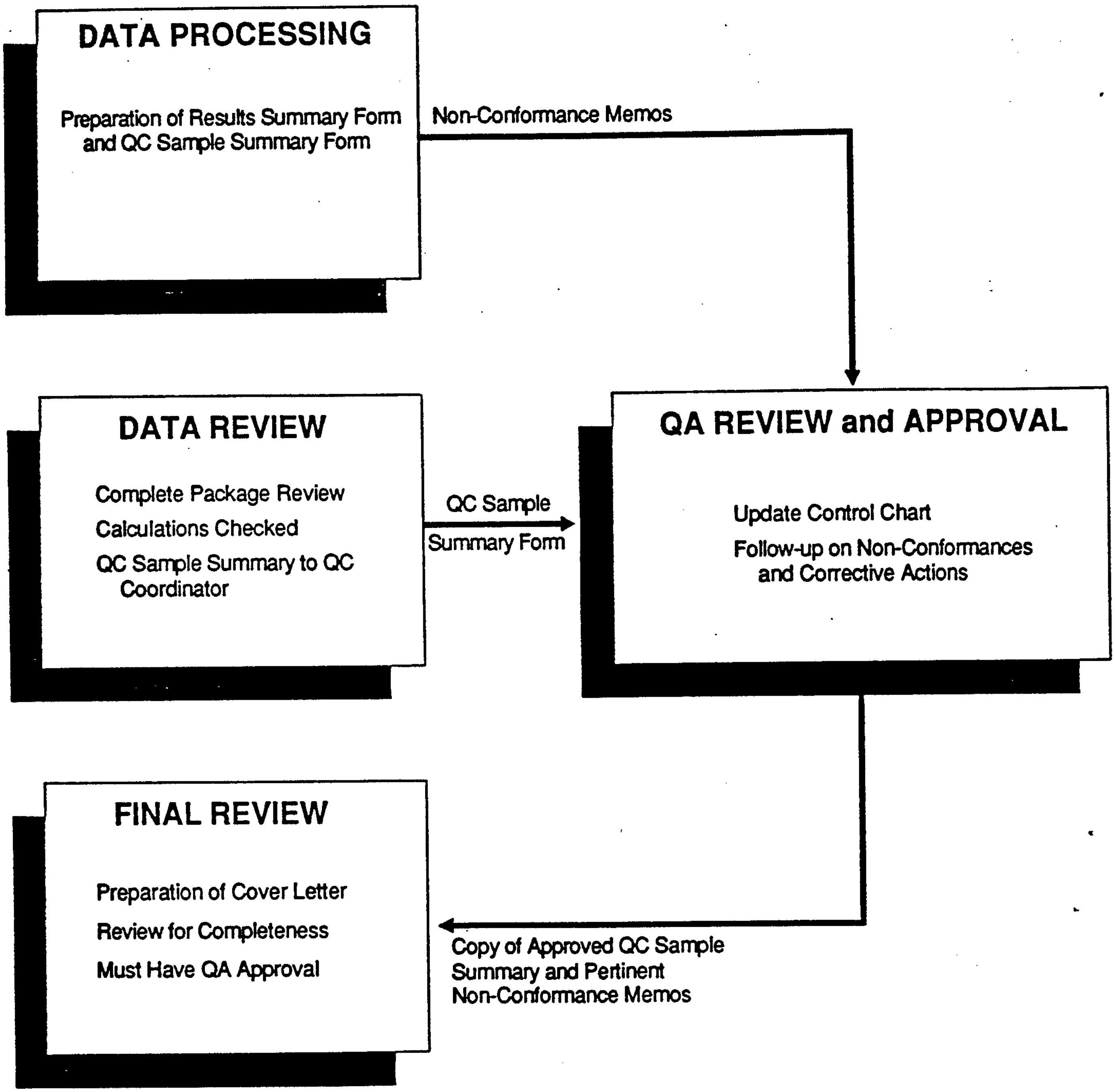


FIGURE 3

DATA REDUCTION, VALIDATION, AND REPORTING SCHEME

TABLE 1

GOALS FOR PRECISION AND ACCURACY FOR ANALYTES AT BEALE AFB

Parameter	Precision as RPD Soil	Accuracy as PR Soil
Matrix Spike/Spike Duplicates:		
Volatile Aromatics		
Benzene	28%	39-150%
Toluene	31%	46-148%
Chlorobenzene	29%	55-135%
Total Fuel Hydrocarbons		
Gasoline	25%	75-125%
Diesel	25%	75-125%

Key: RPD = Relative Percent Difference.
PR = Percent Recovery.

2.1 Accuracy

Accuracy is a measure of the difference between a measured value and the "true" or accepted reference value. The accuracy of an analytical procedure is best determined by the analysis of a sample containing a known quantity of material and is expressed as the percent of the known quantity which is recovered, or measured. The recovery of a given analyte is dependent upon the sample matrix, method of analysis, and the specific compound or element being determined. The concentration of the analyte relative to the detection limit of the analytical method is also a major factor in determining the accuracy of the measurement.

The accuracy of laboratory measured data will be evaluated by determining the percent recovery of both matrix and blank spike samples as described in Section 8.0. For the measurement of aromatic volatile organics, the recovery of a surrogate spiked into each sample, blank, and standard will also be used to assess accuracy. Accuracy objectives for percent recovery as provided by Engineering-Science Berkeley Laboratory (ESBL) based on current experience are presented in Table 1 for both matrix and surrogate spike samples.

2.2 Precision

Precision is an expression of the mutual agreement between multiple measurement values of the same parameter carried out under similar conditions and reflects the reproducibility of the measurement. For this project, precision will be evaluated by recording duplicate measurements of the same parameter on similar sample aliquots under the same conditions and calculating the relative percent difference (RPD) between the values. The formula for calculating RPD is presented in Section 11.0. The data quality objectives for precision, calculated as the RPD between duplicate analyses, are presented in Table 1.

It must be noted that for analytes which are present at concentrations of less than five to ten times the method detection limit (MDL), the RPD objectives indicated in Table 1 are unlikely to be met. Furthermore, if the analyte is present at a concentration below the detection limit, then RPD cannot be calculated. To eliminate this problem, therefore, ESBL prepares matrix spikes in duplicate, and uses the analysis results of the two spiked samples to calculate the RPD.

2.3 Completeness

Completeness is a measure of the amount of valid data obtained from the measurement system relative to the amount anticipated under ideal conditions. The QC objective for completeness is generation of valid data for at least 90 percent of the analyses planned and requested.

2.4 Representativeness

Samples must be representative of the environmental media being sampled. Selection of sample locations and sampling procedures will incorporate consideration of obtaining the most representative sample possible and sample handling procedures are designed to assure that contamination is not introduced. In addition to decontamination of all sampling equipment between samples, trip blanks will also be prepared and analyzed as described in Section 8.0 to evaluate the potential for contamination and to ensure that established sampling equipment decontamination, sample container preparation and sample shipment and handling techniques have been adhered to.

In addition, the assessment of representativeness also must consider the degree of heterogeneity in the material from which the samples are collected. Sampling heterogeneity will be evaluated through the analysis of field duplicate samples, coded to ensure that the samples are treated and analyzed as separate samples. ESBL will make every reasonable effort to assure that the samples are adequately homogenized prior to taking aliquots for analysis, so that the reported results are representative of the sample received. It must be recognized that many means of homogenization expose the sample to significant risk of contamination or loss through volatilization, and should be avoided if possible.

2.5 Comparability

Comparability expresses the degree of confidence with which one data set can be compared to another. The comparability of all data collected for this project will be ensured by adherence to standard sample collection and field measurement procedures and by reporting each type of data in consistent units. No mixtures of standard and metric units will be reported for concentrations, depths, distances, elevations, or velocities. Analysis data will be reported in consistent units of milligrams per kilogram (mg/kg) or micrograms per kilogram (µg/kg) for soil samples, or in the units required by the specified analytical methods.

3.0 SAMPLING PROCEDURES

During soil sampling operations, measures will be made of the air and soil. Air samples will be measured for health and safety purposed as described in the Health and Safety Plan. Soil samples will be measured for total ionizable vapors using a photoionization detector (PID). This will be done to help characterize the vertical and lateral extent of any contamination. A minimum of one PID reading will be made from each location of the collected sample. Sample locations in the soil pile will be noted.

PID soil readings will be made by placing some of the sample soil in a zip-lock plastic bag and sealing it along with some air. After allowing a few minutes for volatilization to occur, the PID pump intake will be inserted into the bag and the reading recorded.

As each sample is collected, the information will be logged into the field notebook, and then transferred to the sample label. The label will contain: the sample ID; date and time sampled; location (and depth, if appropriate); client; analytical method; sample

preservation method; and sampler's initials. The labels will be affixed to a clean, dry surface on the sample container.

Chain-of-custody forms will be filled out as the samples are collected so that samples do not have to be removed from the refrigerated cooler except for potential repacking prior to shipment. No sample will be shipped without a chain-of-custody record, label, and field book documentation.

All field documents, log books, sample labels, and chain-of-custody forms will be filled out legibly in waterproof ink. These documents will be part of the project's permanent file. If corrections are required, the correction will be made by entering the correct data, crossing out the error, and initialing and dating both. The incorrect information will not be obliterated.

If replacement labels or chain-of-custody forms are required, they will be marked with a reference to the previous document. None of these records will be discarded or destroyed.

4.0 SAMPLE CUSTODY

Due to the evidentiary nature of sample collecting investigations, the possession of samples must be traceable from the time the samples are collected until analysis is completed. Therefore, the sample custody, documentation, and handling procedures described in this section will be followed throughout this project.

After collection and containerization, samples will be maintained under chain-of-custody procedures. Each person involved with the sample must know and adhere to chain-of-custody procedures.

4.1 Field Operations

Samples may be shipped to the laboratory by an overnight express service or delivered by courier. Sample containers will be packed and sealed in the following manner:

1. Select a sturdy cooler in good repair. Secure and tape the drain plug with fiber tape. Line the cooler with a large heavy-duty plastic bag.

2. The ends of all brass tubes should be sealed with Teflon tape and plastic non-reactive caps. There should be no air between the sample and the Teflon tape.

3. Be sure the caps on all brass tubes are tight (will not leak) and then secure the cap to the brass tube with tape to insure the cap will not vibrate loose during transport.

4. Wrap individual samples in separate and appropriately sized polyethylene bags. Seal the bags with Teflon tape.

5. Put "blue ice" (or ice that has been placed in heavy duty polyethylene bags and properly sealed) on top of or between the samples. Fill all remaining space between the samples with bubble pack or packaging material. Securely fasten the top of the large garbage bag with tape (preferably plastic electrical tape).

6. The signed chain-of-custody form will be either hand-delivered with the samples to the laboratory or, if the samples are to be shipped, placed in a sealed plastic polyethylene bag and taped to the inside lid of the sample cooler. The cooler will then be closed and securely taped (preferably with fiber tape). Custody seals (optional) should be affixed to the top and sides of the cooler so that the cooler cannot be opened without breaking the seal.

7. The shipping containers must be marked "THIS END UP," and arrow labels which indicate the proper upward position of the container should be affixed to the container. A label containing the name and address of the shipper shall be placed on the outside of the container. Labels used in the shipment of hazardous materials (such as Cargo Only Aircraft, Flammable Solids, etc.) are not permitted on the outside of the container used to transport environmental samples.

Samples will be delivered to Engineering-Science, Berkeley Laboratory, 600 Bancroft Way, Berkeley, California. This is a State of California Department of Health Services certified laboratory. A formal Chain-of-Custody form will accompany each shipment. Examples of Chain-of-Custody forms, sample labels, and custody seals are shown in Figures 4 and 5, respectively.

ENGINEERING – SCIENCE, INC.
CHAIN OF CUSTODY RECORD

LAB:

PAGE___ OF___

CLIENT: ENGINEERING-SCIENCE, INC. BERKELEY	PROJECT MANAGER:	PROJ. NO.:
PROJECT NAME / LOCATION:		
SAMPLER(S): (SIGNATURE)		

SAMPLE ID	DATE	TIME	MATRIX	SAMPLE LOCATION	NO. OF CONTAINERS	ANALYSES REQUIRED					PRESERVED	TO BE COMPOSITED BY LAB	TURNAROUND TIME	REMARKS

RELINQUISHED BY: (SIGNATURE)	DATE/TIME	RECEIVED BY: (SIGNATURE)	RELINQUISHED BY: (SIGNATURE)	DATE/TIME	RECEIVED BY: (SIGNATURE)
RELINQUISHED BY: (SIGNATURE)	DATE/TIME	RECEIVED FOR LABORATORY BY: (SIGNATURE)	DATE/TIME	REMARKS	

DISTRIBUTION: ORIGINAL ACCOMPANIES SHIPMENT; COPY TO COORDINATOR FIELD FILES

FIGURE 4

SAMPLE LABEL

ES ENGINEERING—SCIENCE
LABORATORY SERVICES DIVISION
600 BANCROFT WAY, BERKELEY, CALIFORNIA 94710
TELEPHONE 415/841-7353

DATE	TIME	COLLECTED BY
CLIENT SAMPLE ID		
SAMPLE TYPE		
TESTS REQUIRED	PRESERVATIVE	
	Container # of	

CHAIN OF CUSTODY SEAL

UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY
OFFICIAL SAMPLE SEAL

SAMPLE NO.	DATE	SEAL BROKEN BY	DATE
SIGNATURE			
PRINT NAME AND TITLE *(Inspector, Analyst or Technician)*			

EPA FORM
7500-(R7-75)

4.2 Laboratory Operations

Engineering-Science Berkeley Laboratory (ESBL) has designated a Sample Custodian who is responsible for maintaining custody of the samples and for maintaining all associated records documenting that custody. Upon receipt of the samples, the Sample Custodian will check the original Chain-of-Custody documents and compare them with the labeled contents of each sample container for correctness and traceability. The Sample Custodian will check all sample containers for integrity and will note any observations on the original Chain-of-Custody Record; he then signs the Chain-of-Custody Record, and records the date and time received. Each sample will be logged into the laboratory by assigning it a unique sample number. All samples received as part of the same shipment, up to twenty samples, will receive the same work order number. Each container of the sample is identified by appending sequential letters to the end of the sample ID. The laboratory number and the field sample identification number will be recorded on the laboratory report. Samples will be stored and analyzed according to the methods specified in this QAPP.

5.0 CALIBRATION PROCEDURES AND FREQUENCY

The PID will be calibrated once per day following manufacturer's procedures using surrounding air and 100 parts per million isobutylene as gas standards. The isobutylene standard is obtained from Alphagaz, a commercial supplier.

6.0 ANALYTICAL PROCEDURES

6.1 Laboratory Analytical Requirements

The laboratory analytical requirements for the project are outlined in Table 2. The methods referenced are from the following:

- USEPA, Test Methods for Evaluating Solid Wastes, SW-846, 3rd Edition.
- American Society Testing Materials Manual.
- California Department of Toxic Substances Control (DTSC) Leaking Underground Fuel Tank (LUFT) Manual.

6.2 Method Description

Also presented in Table 2 are recent ESBL method detection limits (MDLs).

Method detection limits are determined semi-annually, by calculating the standard deviation of the results from seven replicate analyses, and multiplying by 3.148.

The Gas Chromatograph is calibrated by analyzing standard solutions at five different known concentrations, and calculating the response factors for each standard. If the relative standard deviation (RSD) of the response factors is less than 30 percent, the response is considered linear, and the average response factor is used. If the RSD is greater than 30 percent, then a calibration curve is prepared. Prior to each day's analyses, and after every 10 samples, a mid-range standard is analyzed. If the response factor differs by more than ±15 percent, the instrument is recalibrated, and the samples run since the last in control continuing calibration check are reanalyzed.

7.0 DATA REDUCTION, VALIDATION, AND REPORTING

Pertinent data collected during the project investigation tasks will be identified and reported to the Project Manager for weekly validation. All raw data (field measurements) used in preparing project reports will be included in appropriate appendices with the project reports.

7.1 Field Measurement Data

Field measurements will be made by competent field geologists and engineers, environmental analysts, and technicians. The following standard reporting units will be used during all phases of the project:

- Soil sampling depths will be reported to the nearest 1.0 foot.

- Locations of samples will be determined to an accuracy of ±1 foot.

Surveys will be performed by a certified land surveyor. All bench marks used will be traceable to either a USCGS or USGS survey marker.

TABLE 2

ANALYTICAL METHODS FOR BEALE AFB

Parameter	Method Number	Matrix	Reporting Units	MDL
Aromatic Volatile Organics	SW8020 (a)			
Benzene		Soil	µg/kg	.554
Toluene		Soil	µg/kg	.951
Ethylbenzene		Soil	µg/kg	.438
Xylenes		Soil	µg/kg	1.933
Chlorobenzene		Soil	µg/kg	.442
o-Dichlorobenzene		Soil	µg/kg	.372
m-Dichlorobenzene		Soil	µg/kg	.442
p-Dichlorobenzene		Soil	µg/kg	.402
Total Fuel Hydrocarbons Gasoline/Diesel		Soil	mg/kg	0.5/10

Method References:

(a) USEPA, Test Methods for Evaluating Solids Wastes, SW-846, 3rd Edition.
(b) California DTSC, Leaking Underground Fuel Tank (LUFT) Manual.

During processing of field data, validation checks will be performed by individuals designated by the project manager. The purpose of these checks is to identify "outliers"; that is, data which do not conform to the pattern established by other observations. Because of the limited number of observations, detailed statistical analysis of the data to be obtained during this program is not feasible and the principal method of validation will be routine checks to assure that data is correctly transcribed and that reported identification codes and sampling information match the corresponding information in the field records. In addition, data will be compared against that obtained in previous investigations (where available) and against applicable standards and guidelines. Any observation which exceeds 80 percent of an applicable standard or the maximum value observed in previous investigations at a specific site will be individually verified.

Although outliers may be the result of transcription errors or instrumental breakdowns, they may also arise from a greater degree of spatial or temporal variability than expected. Therefore, after an outlier has been identified, a decision must be made concerning its further use. Obvious mistakes in data will be corrected when possible, and

the correct value will be inserted. If the correct value cannot be obtained, the data may be excluded. An attempt will be made to explain the existence of the outlier. If no plausible explanation can be found for the outlier, an attempt will be made to determine the effect of the outlier when both included and excluded in the data set and the results will be discussed in the Informal Technical Information Report (ITIR).

7.2 Gas Chromatography Data

Compounds are identified and quantitated by data reduction programs in the gas chromatograph data system. Identity is based on retention time. All positive identifications and quantitations are checked by an analyst. Quantitation is performed by the data system using the internal standard calculation suggested in Method 8020. A multipoint calibration table is generated and response factors are calculated for each point using the formula specified in the method.

These response factors must meet criteria specified in the method protocol. The average response factor is calculated. Concentrations of analytes in samples are calculated using the formula required by the method. All values are calculated on the basis of a 5.0 milliliter or 5.0 gram sample, using the formulas specified in the Methods.

The identity of all analytes present in concentrations above the Method Detection Limit (MDL) for Gas Chromatography (GC) methods will normally be confirmed by second column GC analysis. Second column results are reported as "detected" or "not detected." Analytes which cannot be confirmed will be reported as "not detected" in the body of the report. The results of both the first and second column analysis will be provided in the ITIR as well as in the analytical data appendix to the Characterization Technical Report.

Quality control (QC) consists of a daily check of the calibration. If any response factor for a compound of interest does not agree with the average response factor within limits set by the method, the system is recalibrated. Blanks are analyzed as described in the method, plus whenever the analyst feels it is necessary. All samples are spiked with surrogates. If surrogates or matrix spikes are out of control, corrective action steps are taken as described in the method being used. Samples that have been determined to be out of control must be documented in the laboratory logbook along with the corrective

action taken (e.g., reanalyses). If the corrective action is ineffective, the results of the QC "run" will be flagged as not within control limits when reported in the data package.

Spiking solutions are prepared by different analysts from those who prepare the standards. This ensures an independent comparison for all spiked samples.

7.3 Reporting

Reporting of analytical results for this project will contain data sheets and the results of analysis of QC samples. Analytical results reports will contain the following items.

- Project identification.
- Field sample number.
- Laboratory sample number.
- Sample matrix description.
- Date and time of sample collection.
- Analytical method description and reference citation.
- Individual parameter results.
- Date of analysis (extraction, first run, and subsequent runs).
- Detection limits achieved.
- Dilution or concentration factors.
- Corresponding QC report.

Analytical results for GC analysis shall be reported based on quantitation on the first column unless precluded by interferences. In such cases, the second column results may be used.

Quality control results are calculated and reviewed by the laboratory supervisor to determine the accuracy and precision of the analytical results. The Laboratory Supervisor or the Laboratory Director reviews all final reports and associated quality

control data. Results are recorded on the QC report forms for the appropriate tests and correlated to the analysis results by the QC report number. The QC results are used to prepare control charts for each test and type of matrix.

Analytical results reports for any given sample or sample shipment shall be submitted within four weeks of sample receipt by the laboratory. The quality control report shall be submitted with the analytical results report.

The Project QA Officer shall notify ESBL of any rejection of reports within four weeks following receipt. Any reports which are rejected as incomplete or in error will be returned to the laboratory for correction. The laboratory shall submit a revised, corrected report within two weeks of the receipt of a rejected report returned by the PQAO.

Chromatograms and reports from all analyses are saved in appropriate files.

The flagging of results will consist of the USEPA Contract Laboratory Program data flags. Each analytical report will contain a data flagging key for both organic and inorganic analyses.

Analytical results between the MDL and the TRL will be reported as estimated. If the analyte is not detected during the analysis, it will be reported as "ND."

8.0 INTERNAL QUALITY CONTROL CHECKS FOR FIELD AND LABORATORY OPERATIONS

8.1 Field Quality Control Checks

Field quality control checks are used to assess the representiveness of the sampling. They are designed to determine what effects activities such as sample collection, containerizing samples, shipping, and storage have on sample integrity and to ensure that samples available for analysis in the laboratory are representative of actual conditions on site. Field quality control checks include trip blanks, field blanks, bottle blanks, and field duplicates.

8.1.1 Trip Blanks

Volatile organics samples are subject to loss of sample integrity by the diffusion of volatile contaminants under the Teflon-lined silicone rubber septum of the sample vial.

Therefore, trip blanks are prepared and analyzed to monitor for this type of contamination during sample shipment and handling. Trip blanks are prepared by filling two VOA vials with Type II Reagent Grade Water and accompany the sample vials from the laboratory to the field and back to the laboratory. They are kept with the sample vials and/or soil sampling equipment at all times. One trip blank will accompany each sample shipment. All trip blanks will be analyzed for VOCs, and in the event that compounds of interest are detected in the analysis of the trip blanks at concentrations above the quantitation limit, the data from the associated samples will be qualified if the concentrations in the samples are less than five times that in the trip blanks.

8.1.2 Field Duplicate Samples

One field duplicate will be collected for ten percent of soil samples. Field duplicates are collected as a separate sample, and not as splits, to allow for the assessment of the representativeness of the sampling procedures. The RPDs calculated for field duplicates arise from two sources of uncertainty: normal analytical uncertainty and sample collection uncertainty, which includes sample heterogeneity. Thus, RPDs calculated for the field duplicate cannot be assessed by the same criteria established for the analytical precision assessment. Soil samples will be collected as duplicates and not replicates (splits) as discussed in the OEHL Handbook (1989) since the soil sampling method does not allow splitting of samples.

8.2 Laboratory Quality Control Checks

8.2.1 Method Blank

- GC (Volatiles) - Analyses for volatile aromatic compounds include a blank analysis of the laboratory reagent water. The blank is analyzed with each set of samples or more often as required to avoid carryover between samples. The concentration of target compounds in the blanks must be less than or equal to the quantification limits with the exception of common laboratory solvents (such as toluene) for which a control limit of 5x the quantification limit is used.

8.2.2 Matrix Spiked Samples

As part of the method, samples representing major categories of analyses will be spiked. For the organic compound and metals, Table 3 lists the compounds that will likely be used to spike the samples.

- GC - Each set of samples (a maximum of twenty samples per set) is analyzed with a matrix spiked sample and a matrix spiked duplicate. The spiking compounds for volatiles matrix spike and surrogate analyses are shown in Table 3. The control limits for percentage recovery (%R) and relative percentage difference (RPD) for these compounds are shown in Table 1. The matrix spike compounds used for other GC analyses are selected based on the method used and the target compounds requested. The control limits for %R and RPD are determined by the use of laboratory control charts or EPA recommended limits when available.

8.2.3 Lab Control Standards (Check Standards)

A minimum frequency of 5 percent check standards will be used with a sample batch where feasible. Calibration standards will be prepared in accordance with the methods used.

8.2.4 Control Charts

GC - Samples analyzed for volatile organics are spiked with the surrogate compound trifluorotoluene. The commonly used internal standards are used for determining surrogate recoveries for other GC methods. The %R for the surrogate compounds is compared to analysis control charts to determine the acceptance limits.

8.2.5 Control Limits

Quality control checks, their frequency, acceptance criteria, and the corrective action if out-of-limits are summarized in Table 4.

9.0 PERFORMANCE AND SYSTEMS AUDITS

Both performance and systems audits will be performed during the lifetime of the project. They will be planned, scheduled, and conducted by the Project QA Officer, or

TABLE 3

MATRIX SPIKING AND SURROGATE COMPOUNDS TO BE USED FOR ANALYTICAL QUALITY CONTROL FOR BEALE AFB ANALYSES

Volatile Aromatic Organics:		
	MS/MSD:	Benzene Toluene Chlorobenzene
	Surrogate:	Trifluorotoluene
Total Fuel Hydrocarbons:		
	MS/MSD:	Gasoline Diesel
Total Lead:		
	MS/MSD:	Lead

Key: MS/MSD = Matrix spike and matrix spike duplicate.

TABLE 4
SUMMARY OF INTERNAL QUALITY CONTROL PROCEDURES

Analytical Method	Parameter	Quality Control Check	Frequency	Acceptance Criteria	Corrective Action
8020	Volatile Aromatics	<u>Field (QC):</u> Trip Blank	1 per batch of samples shipped to lab	Target compounds at concentrations ≤3x the detection limits in Table 2-1 of the IRP handbook	• Check laboratory reagent blank for possible laboratory problem • Flag sample data
		Field duplicate	As described in Section 2.2.4	RPD ≤ 50%	• Review and compare to laboratory QC • Flag data where appropriate • Discuss results and implications
		<u>Laboratory QC:</u> Method blank	1 per day or as needed to avoid carryover	Target compounds at concentrations ≤ detection limit except common laboratory contaminants which shall be ≤3x the detection limits in Table 2-1 of the IRP handbook	• Check GC system • Reanalyze blank • Generate non-conformance memo • Flag data
		Run initial calibration	As required by continuing calibration check	As described in Section 1.8.2	• Check GC system • Rerun as required to meet criteria
		Continuing calibration check	Minimum of once per day	As described in Section 1.8.2	• Check GC system • Run new initial calibration
		Surrogate Spike	All blank, standards, QC samples, field samples	See Table 1	• Reanalyze • If reanalysis results similar discuss in case narrative • Generate non-conformance memo

TABLE 4 (continued)

Analytical Method	Parameter	Quality Control Check	Frequency	Acceptance Criteria	Corrective Action
		Matrix spike/ spike duplicate	1 pair every 20 project samples	See Table 1	• Check laboratory control sample for possible laboratory problem • Discuss in case narrative • Issue non-conformance memo
		Laboratory control sample (Blank spike)	As needed	See Table 1	• Discuss in case narrative • Issue non-conformance memo
Modified 8015	Gasoline	<u>Field QC:</u>			
		Field Duplicate	As described in Section 2.2.4	RPD $\leq$ 50%	• Check calculation • Review and compare with laboratory QC • Discuss in report
		<u>Laboratory QC:</u> Method blank	1 per day	Target compounds at concentrations $\leq$3x the detection limits in Table 2-1 of the IRP handbook	• Check GC system • Reanalyze blank
		Initial calibration	As required by continuing calibration check	Correlation coefficient of curve $\geq$ 0.995	• Check GC system • Rerun to meet criteria
		Continuing calibration	Minimum of once per day	% difference of midpoint standard $\leq$ 15%	• Check GC system • Recalibrate GC
		Surrogate Spike	Every sample (blanks, standards, QC, field)	See Table 1	• Check calculations • Flag data • Generate non-conformance memo

TABLE 4 (continued)

Analytical Method	Parameter	Quality Control Check	Frequency	Acceptance Criteria	Corrective Action
		Matrix Spike/ Spike Duplicate	1 pair per 20 project samples	See Table 1	• Check calculations • Compare with laboratory control sample • Discuss in case narrative • Issue non-conformance memo
		Laboratory control sample	As needed	See Table 1	• Discuss in case narrative • Issue non-conformance memo
Modified 8015	Diesel	Field QC: Equipment blank	As described in Section 2.2.4	Target compounds at concentrations $\leq$3x the detection limits in Table 2-1 of the IRP handbook	• Check laboratory reagent blank • Flag sample data
		Field Duplicate	As described in Section 2.2.4	RPD $\leq$ 50%	• Check calculation • Review and compare with laboratory QC • Discuss in report
		Laboratory QC: Method blank	1 per 20 samples or once per day	Target compounds at concentrations $\leq$3x the detection limits in Table 2-1 of the IRP handbook	• Check GC system • Reanalyze blank
		Initial calibration	As required by continuing calibration check	Correlation coefficient of curve $\geq$ 0.995	• Check GC system • Rerun to meet criteria • Generate non-conformance memo
		Continuing calibration	Minimum of once per day	% difference of midpoint standard $\leq$ 15 %	• Check GC system • Recalibrate GC

TABLE 4 (continued)

Analytical Method	Parameter	Quality Control Check	Frequency	Acceptance Criteria	Corrective Action
		Matrix Spike/ Spike Duplicate	1 pair per 20 project samples	See Table 1	• Check calculations • Reanalyze • Flag data • Issue non-conformance memo
		Laboratory control sample (Blank Spike)	As needed	See Table 1	• Discuss in case narrative • Issue non-conformance memo

designated alternate. The audits will be implemented to evaluate the capability and performance of project and subcontractor personnel, items, activities, and documentation. Audit findings will be generated by the QA Officer and submitted to the Project Manager for corrective action.

As part of its on-going Quality Assurance Program, ESBL participates in USEPA interlaboratory performance studies. Four times each year, USEPA sends blind check samples to the laboratory for analyses. Two of these are for evaluation of wastewater analyses; two are for evaluating performance of drinking water analysis. These results are sent by USEPA to the state of California Department of Toxic Substances Control. They are used, along with periodic site audits by DTSC personnel and required submittals of example data packages, to evaluate the laboratory for initial and continuing certification for both drinking water and hazardous waste analyses.

In addition to CAL EPA certification, ESBL maintains Approved and/or Certified status with USEPA Superfund Innovative Technology Evaluation (SITE) program, US Department of Energy (USDOE) Hazardous Waste Remedial Action Program (HAZWRAP), US Army Corps of Engineers (USACOE), and the New York State Department of Environmental Conservation (NYSDEC).

10.0 PREVENTIVE MAINTENANCE

10.1 Field Equipment

Equipment, instruments, tools, gauges, and other items requiring preventive maintenance will be serviced in accordance with manufacturer's specified recommendations and written procedures developed by the operators. Preventive maintenance for all equipment includes inspection before use, cleaning as necessary during use, and thorough cleaning and inspection after use. Rechargeable batteries are checked before use and recharged after use, and for equipment using disposable batteries, replacement batteries are stocked at all times. Equipment failures are repaired in the field, if possible, or returned to the manufacturer for repair.

10.2 Laboratory Instruments

Analytical instruments are serviced at intervals recommended by the manufacturer. Service contracts for regular maintenance and emergency service are maintained for major instruments. An instrument repair maintenance log book is kept for each instrument. Entries include the date of service, type of problem encountered, corrective action taken, and initials and affiliation of the person providing the service.

The instrument use log book is monitored by the analysts to detect any degradation of instrument performance. Changes in response factors or sensitivity are used as indications of potential problems. These are brought to the attention of the laboratory supervisor and preventative maintenance or service is scheduled to minimize down time. Back-up instrumentation and an inventory of critical spare parts are maintained to minimize delays in completion of analyses.

11.0 PROCEDURES USED TO ASSESS DATA PRECISION, ACCURACY, AND COMPLETENESS

Performance of the following calculations will be documented and included in the QC section of each analytical report submitted by ESBL.

11.1 Accuracy

Accuracy is the degree to which the measured value reflects the "true" value. Accuracy is normally measured as the percent recovery (%R) of a known amount of analyte, called a spike, added to a sample (matrix spike) or to a blank (blank spike). Percent recovery is calculated as follows:

$$\%R = \frac{SSR - SR}{SA} \times 100,$$

where:

%R = Percent Recovery.

SSR = Value obtained by analyzing the sample with the spike added.

SR = The background value, i.e.; the value obtained by analyzing the sample.

SA = Concentration of the spike added to the sample.

The acceptance limits for accuracy for each parameter are presented in Table 1.

11.2 Precision

Precision is the degree of mutual agreement among repeated individual measurements of the same parameter made under identical conditions. Relative percent difference (RPD) will be used to estimate the precision of data measurement methods for the Beale Air Force Base project. RPD is calculated as follows:

$$RPD = \frac{100\,(abs(X_1 - X_2))}{(X_1 + X_2)/2},$$

where:

X_1 = the first measurement of the parameter,

X_2 = the second measurement of the parameter,

$abs(X_1 - X_2)$ = the absolute value of the difference between the two measurements,

$(X_1 + X_2)/2$ = the mean of the two measurements.

To ensure the measurement of precision as RPD even when the concentrations of an analyte is below quantitation limits, RPD data will be generated by preparing matrix spikes in duplicate, and calculating the RPD between these duplicate spikes. For all GC and GC/MS analyses, precision data will be limited to RPDs between the spiking compounds listed in Table 1, where the RPD acceptance criteria are also presented.

11.3 Completeness

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the total amount expected to be obtained under ideal conditions. A target of 90 percent completeness, calculated for each analysis method, has been established as the overall project objective.

12.0 CORRECTIVE ACTION

The following procedures have been established to assure that conditions adverse to quality, such as malfunctions, deficiencies, deviations, and errors, are promptly investigated, documented, evaluated, and corrected.

When a significant condition adverse to quality is noted at the sampling site, analytical laboratory, or subcontractor location, the cause of the condition will be determined and corrective action taken to preclude repetition. Condition identification, cause, reference documents, and corrective action planned to be taken will be documented and reported to the site investigation team leader, Project Manager, Project QA Officer, and involved subcontractor management, as a minimum. Implementation of corrective action is verified by documented follow-up action. All project personnel have the responsibility, as part of the normal work duties, promptly to identify, report, and solicit approval of corrective actions for, conditions adverse to quality.
Corrective actions may be initiated:

- when predetermined acceptance criteria are not attained (objectives for precision, accuracy, and completeness)
- when the prescribed procedure, or any data compiled are found to be faulty
- when equipment or instrumentation is determined to be faulty
- when the traceability of samples, standards, and/or analysis results are questionable
- when quality assurance requirements have been violated
- when designated approvals have been circumvented
- as a result of systems or performance audits
- as a result of a management assessment
- as a result of intralaboratory or interlaboratory comparison studies
- at any other instance of conditions significantly adverse to quality.

12.1 Procedure Description

Project management and staff, such as field investigation teams, quality assurance auditors, document and sample control personnel, and laboratory groups, monitor on-going work performance in the normal course of daily responsibilities. Work is supervised at field sites by the Field Team Leader.

Work is audited at the sites, laboratories, and subcontractor locations by the Project QA Officer and/or designated alternate. Items, activities, or documents ascertained to be in noncompliance with quality assurance requirements will be documented and corrective actions mandated through the audit report. Audit Findings are logged, maintained, and controlled by the Project Quality Assurance Officer (PQAO).

Following identification of an adverse condition or quality assurance problem, notification will be made to the project manager and senior individual in charge of the activity found to be deficient, along with recommendations for correction. The senior individual in charge of the activity found to be deficient will initiate corrective action. The Project QA Officer will approve such corrective actions. A record of this notification will be attached to the audit report. Following implementation of corrective action, the senior individual in charge will report actions taken and results to the Project Manager. A record of action taken and results will also be attached to the audit report.

12.2 Out-of-Control Events and Corrective Action

Finding and correcting sampling and analysis problems are the responsibility of everyone working on the project. Many corrective actions must be documented in the laboratory or in the field and do not require the action of upper management. However, it is important to document these occurrences and to make immediate corrections. All personnel will be made aware of the need to report problems and to correct problems promptly.

Examples of non-conformance memoranda currently in use at ESBL are attached at the end of this section.

13.0 QUALITY ASSURANCE REPORTS

At monthly intervals throughout the project, the PQAO will submit a report to project management which will discuss the QA activities of that month. These reports will include discussions of any conditions adverse or potentially adverse to quality, such as responses to the Findings of any field or laboratory audits; any field, laboratory, or sample conditions which necessitate a departure from the methods or procedures specified in this QAPP; field sampling errors; and any missed holding times or problems with laboratory QC acceptance criteria, and the associated corrective actions undertaken. Such reports shall not preclude immediate notification to project management of such problems when timely notice can reduce the loss or potential loss of quality, time, effort, or expense.

These reports shall be reviewed by the Project Manager and Project Technical Director, for completeness and the appropriateness of any corrective actions. They shall be retained in the project files, and shall be summarized in the QA Report included in the final project documents.

At the conclusion of the project sampling and analysis, as a part of the Informal Technical Information Report, a QA report will be submitted. Analytical and QC data will be included, summarizing data quality information for the project.

In the final report, both laboratory and field QC data will be presented, including a summary of QA activities and any problems and/or comments associated with the analytical and sampling effort. Any corrective actions taken in the field, results of any audits, and any modifications to laboratory protocols will be discussed.

ENGINEERING-SCIENCE, INC.

Copied to:
Case/W.O. File [ ]
Project Manager [ ]
____________ [ ]

NONCONFORMANCE MEMO
Sample Receiving

Project/Client No.:______________________ Project/Case No.:______________________

Date Initiated:______________ By:______________________________

W.O/Sample No(s).:______________________________________

NONCONFORMANCE: (Check applicable item(s):

_____(1) Not enough sample sent for proper analysis.
_____(2) Sample bottle received broken and/or cap not intact.
_____(3) Custody seal missing and/or broken.
_____(4) Samples received without proper preservation (refrigeration) when it has been deemed necessary.
_____(5) Illegible sample numbers or label missing from bottle.
_____(6) Numbers on sample not the same as numbers on paperwork.
_____(7) Incomplete instructions received with sample(s), i.e., no Request for Analysis, no Chain-of-Custody, incomplete billing instructions, no due dates, etc.
_____(8) Samples received in improper container.
_____(9) Physical characteristics different than those on sampling sheets, i.e., two phases.
_____(10) Standard operating procedure not adhered to (specify)
____
_____(11) Other (specify) ______________________________________
____

CORRECTIVE ACTION TAKEN: (Check applicable item(s):

_____(1) Client informed verbally.
_____(2) Client informed by memo/letter.
_____(3) Sample processed "as is".
_____(4) Resampling requested.
_____(5) Samples "on hold" until further notice.
_____(6) Other (specify) ______________________________________
____

CORRECTIVE ACTION TAKEN BY:

Title	Initials	Date	Corrective Action No.
Sample Custodian	______	______	______
Scheduling Coordinator	______	______	______
Client Services	______	______	______

When completed, forward to QA Manager for distribution. Original will be maintained in QA files.

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Copied to:
Case/W. O. File [ ]
Project Manager [ ]
______________ [ ]

NONCONFORMANCE MEMO
Extractions/Sample Prep

Client:______________________________ Work Order No.:________

Date Initiated:______________ By:______________________________

Laboratory Sample No(s).:______________________________

Procedure:______________________________

NONCONFORMANCE: (Check applicable item(s):

____(1) Method development or modification, to include any extraction or cleanup sequence not currently used on a regular basis in the extractions lab. (Requires QA approval). PLEASE SPECIFY______________

____(2) Sample matrix not described on paperwork, i.e., supposed to be organic, but is actually aqueous, nonhomogeneity, etc. PLEASE SPECIFY ______________

____(3) Error in spiking or surrogating

____(4) Lost extract

____(5) Lost sample

____(6) Exceeded holding time by _____(days)

____(7) Other (PLEASE SPECIFY) ______________

CORRECTIVE ACTION TAKEN: (Check applicable item(s):

____(1) Error corrected by technician/analyst

____(2) Situation noted on Sample Extraction Record and appropriate lab personnel notified (SPECIFY)

____(3) Sample processed "as is"

____(4) Re-extraction or resampling requested/performed

____(5) Sample put "on hold" until further notice

____(6) Client informed verbally

____(7) Client informed by memo/letter

____(8) Other (SPECIFY)

CORRECTIVE ACTION TAKEN BY:

Title	Initials	Date	Corrective Action No.
Technician	______	______	______
Extraction Section Leader	______	______	______
Organic Group Leader	______	______	______
QA/QC Coordinator	______	______	______

When completed, forward to QA/QC for distribution. Original will be maintained in QA/QC Files.

NCEXT-BS-FRM04

Rev. 9/14/89

Copied to:
Case/W. O. File [ ]
Project Manager [ ]
__________ [ ]

NONCONFORMANCE MEMO
GC/MS Data Review

Project/Client No.:__________ Project/Case No.:__________

Date Initiated:__________ By:__________

W.O/Sample No(s).:__________

NONCONFORMANCE: (Check applicable item(s)):

___ (1) Method development or modification to include procedures not currently used on a regular basis (requires QA approval) (SPECIFY)__________

(2) Initial calibration/continuing calibration:

___ (a) % RSD for calibration check compounds (CCC) is greater than method criteria

___ (b) Average Relative Response Factor (RRF) for System Performance Check Compounds (SPCC) is less than method criteria

___ (c) Percent difference (%D) for calibration check compounds (CCC) is greater than method criteria

___ (d) Continuing calibration not performed within 12-hour period

(3) Method blank exceeds criteria:

___ (a) 5X CRQL for common lab contaminants (see CLP-SOW)

___ (b) $\geq$CRQL for other TCL compounds

(4) Surrogate Spike Recoveries exceed criteria:

___ (a) In Method Blank, any one surrogate (B/N, Acid or VOA fraction) is outside required limits

___ (b) In sample, one surrogate in B/N or acid fraction is less than 10% (<10%)

___ (c) In sample, one surrogate in VOA fraction is outside required limits

___ (d) In sample, two surrogates in either B/N or acid fraction are outside required limits

NOTE: See CLP-SOW, pg. E-19 and pg. E-36 for Corrective Action requirements

(5) Matrix Spike/Matrix Spike Duplicate:

___ (a) Not recoverable due to high concentration in original sample

___ (b) Not determinable due to possible sample in-homogeneity

___ (c) Not determinable due to matrix effects

___ (d) % Recovery/%RPD outside prescribed limits

___ (6) Dilution error

(7) Sample non-conformance:

___ (a) Matrix interference

___ (b) Limited sample volume

___ (c) Internal standard areas outside limits

___ (d) Difficulty in quantitation due to pattern alteration and/or interference

___ (e) Retention time of compounds not within established retention time windows

___ (f) Sample saturated GC/MS detector (wrong concentration level)

(8) Calculation/Transcription error:

___ (a) Discovered before report to client

___ (b) Discovered after report to client

___ (9) Holding time exceeded by _____ (days)

___ (10) Other (SPECIFY) __________

NONCONFORMANCE MEMO

GC/MS Data Review

CORRECTIVE ACTION TAKEN (Check applicable item(s):

___ (1) Situation noted on Sample Extraction Record and appropriate lab personnel notified (SPECIFY)______

___ (2) Samples reanalyzed
___ (3) Samples repreped and re-analyzed
___ (4) Method Blank (VOA) reanalyzed
___ (5) Data accepted "as is"
___ (6) Client informed verbally
___ (7) Client informed by memo/letter
___ (8) Project "on hold" until further notice
___ (9) Other (SPECIFY)______

CORRECTIVE ACTION TAKEN BY:

Title	Initials	Date	Corrective Action No.
Analyst	____	____	____
GC/MS Section Leader	____	____	____
Organic Group Leader	____	____	____
Technical Director	____	____	____

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NONCONFORMANCE MEMO
GC Data Review

Project/Client No.:______________________ Project/Case No.:______________________

Date Initiated:______________ By:______________________

W.O/Sample No(s).:______________________

NONCONFORMANCE: (Check applicable item(s):

____(1) Method development or modification to include procedures not currently used on a regular basis (requires QA approval) (SPECIFY) ______________________

(2) Calibration (3pt. or 5pt):

____ (a) Curve not established prior to sample analysis
____ (b) Curve not within % RSD for relative standards
____ (c) Daily check standards deviate > $\pm$ 15% from mean
List compounds out______________________
Present in sample? Yes ______ No ______

____(3) Sample identification/dilution error. (SPECIFY)______________________

(4) Calculation/transcription error (SPECIFY)______________________

____ (a) Error discovered before report to client
____ (b) Error discovered after report to client

(5) Matrix spike/duplicate:

____ (a) Not recoverable due to high concentration in original sample
____ (b) Not determinable due to possible sample inhomogeneity
____ (c) Not determinable due to matrix effects
____ (d) % Recovery/%RPD outside prescribed limits

(6) Specified detection limit unobtainable due to:

____ (a) Matrix interferences
____ (b) Limited sample volume
____ (c) Blank criteria not met
____ (d) Difficulty in quantitation due to pattern alteration and/or interference
____ (e) Surrogate recovery not within suggested limits
____ (f) Retention time of alternating standards or spiked components not within established retention time windows

(7) Sample non-conformance:

____ (a) Matrix interference
____ (b) Limited sample volume
____ (c) Internal standard areas outside limits
____ (d) Difficulty in quantitation due to pattern alteration and/or interference
____ (e) Retention time of compounds not within established retention time windows
____ (f) Sample saturated GC detector (wrong concentration level)

____(8) Standard operating procedure not adhered to. (SPECIFY)______________________

____

____(9) Holding time exceeded by ______ (days)

____(10) Other (SPECIFY)______________________

____

NONCONFORMANCE MEMO

GC Data Review

<u>CORRECTIVE ACTION TAKEN</u> (Check applicable item(s):

____(1) Situation noted on sample tracking sheet and appropriate lab personnel notified. (SPECIFY)
____

____(2) Samples put "on hold" until further notice.
____(3) Spike/standard concentration verified. New solution made if necessary.
____(4) Analysis of data from laboratory blank spikes (BS/BSD) was found to be satisfactory. Therefore, non-compliant matrix spike recoveries (MS/MSD) are probably due to matrix effects. Sample data is to be reported "as is".
____(5) Samples reanalyzed.
____(6) Samples reprepped and reanalyzed.
____(7) Client informed verbally.
____(8) Client informed by memo/letter.
____(9) Other (SPECIFY): ____
____

<u>CORRECTIVE ACTION TAKEN BY:</u>

Title	Initials	Date	Corrective Action No.
Analyst	______	______	______
GC Section Leader	______	______	______
Organic Group Leader	______	______	______
Technical Director	______	______	______

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NONCONFORMANCE MEMO
METALS/INORGANIC LABORATORY

Project/Client No.:______________________________ Project/Case No.:____________________________

Date Initiated:__________________ By:____

W.O/Sample No(s).:____

NONCONFORMANCE: (Check applicable item(s):

___(1) Method development or modification to include any digestion or analysis method not currently used on a regular basis in the Inorganic lab. (requires QA approval) PLEASE SPECIFY
____
____
____
____

___(2) Sample matrix not described on paperwork, i.e., supposed to be organic, but is actually aqueous, nonhomogeneity, etc. PLEASE SPECIFY ____
____
____

___(3) Error in spiking
___(4) Lost digestate or distillate
___(5) Lost sample
___(6) Exceeded holding time by _____ days
(7) Calibration
___ (a) Correlation coefficient of standard curve <0.995
___ (b) ICV, CCV recovery outside prescribed limits
___ (c) CCV's not analyzed at proper intervals
___ (d) ICB, CCB result exceeds the reporting limit
(8) Blank, Blank Spike
___ (a) Preparation blank exceeds 5x reporting limit
___ (b) Blank spike recovery outside prescribed limits
(9) Matrix spike/duplicate:
___ (a) Not recoverable due to high concentration in original sample
___ (b) Not determinable due to possible sample inhomogeneity
___ (c) Not determinable due to matrix effects
___ (d) % Recovery/%RPD outside prescribed limits
___(10) Analytical spike, MSA
___ (a) Analytical spike recovery not between 90% and 110%
___ (b) No MSA performed at client's request
___ (c) MSA performed, correlation coefficient ≥0.995
___ (d) MSA performed, correlation coefficient <0.995
___(11) Sample identification/dilution error (SPECIFY) ______________________________
___(12) Calculation/transcription error (SPECIFY) ________________________________
___ (a) Error discovered before report to client
___ (b) Error discovered after report to client

NONCONFORMANCE MEMO

METALS/INORGANIC LABORATORY

(13) Specified detection limit unobtainable due to:

___ (a) Matrix interferences

___ (b) Limited sample volume

(14) Sample non-conformance:

___ (a) Matrix interference

___ (b) Limited sample volume

___ (15) Standard operating procedure not adhered to. (SPECIFY) ______________________

___ (16) Other (SPECIFY) ______________________

<u>CORRECTIVE ACTION TAKEN</u> (Check applicable item(s):

___ (1) Error corrected by technician/analyst

___ (2) Situation noted on bench sheet or in log book and following lab personnel notified: ______________________

___ (3) Samples put "on hold" until further notice

___ (4) Spike/standard concentration verified. New solution made if necessary

___ (5) Analysis of data from laboratory blank spikes (BS/BSD) was found to be satisfactory. Therefore, non-compliant matrix spike recoveries (MS/MSD) are probably due to matrix effects. Sample data is to be reported "as is"

___ (6) Samples reanalyzed

___ (7) Samples reprepped and reanalyzed

___ (8) Client informed verbally

___ (9) Client informed by memo/letter

___ (10) Verify the calibration and re-analyze the preceding ten samples

___ (11) Other (SPECIFY): ______________________

<u>CORRECTIVE ACTION TAKEN BY</u>:

Title	Initials	Date	Corrective Action No.
Analyst	____	____	____
GC Section Leader	____	____	____
Inorganic Group Leader	____	____	____
Technical Director	____	____	____

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QC NONCONFORMANCE MEMO

Project: ______________________________ Work Order No.: ____________

Date Initiated: ______________ By: ______________________________

MS/MSD Sample No(s).: ______________________________ Section: ____ organic ____ inorganic

NONCONFORMANCE: [Check applicable item(s)]:

____ (1) No Spiked Blank was analyzed.
____ (2) MS and MSD were not analyzed.
____ (3) Blank Spike Recovery is outside (CLP/ESBL control chart) limits.
____ (4) RPD is outside (CLP/ESBL control chart) limits.
____ (5) In the Method Blank, one surrogate is outside the (CLP/ESBL control chart) limits.
____ (6) One Surrogate Recovery in the volatile fraction is outside the limits.
____ (7) In Samples one Surrogate Recovery in the semivolatile is below 10%.
____ (8) In Samples two Surrogate Recoveries in either base neutral or acid fractions are outside the limits.
____ (9) Internal or external check sample result is outside the acceptable criteria.
____ (10) Control charts indicate three consecutive points are outside the warning limits.
____ (11) Control charts indicate eight consecutive points are on the same side of the center line.
____ (12) Control charts indicate six consecutive points are such that each point is larger or smaller than the point immediately preceding it.
____ (13) In the data package, Analysis Result Report is not signed by the Group Leader.
____ (14) In the data package, Analysis Result Report for the Method Blank is not included.
____ (15) In the data package, the quality control report is provided to a commercial client.
____ (16) In the data package, client ID on the cover page and analyses report do not match the COC.
____ (17) In the data package, the data are flagged incorrectly.
____ (18) Nonconformance memo was not issued by the analysis section within two hours of the nonconformance problem being found.

CORRECTIVE ACTION REQUIRED [Please initial applicable item(s)]:

____ (1) Re-analysis is requested.
____ (2) Prepare and re-analyze samples.
____ (3) Recalculate.
____ (4) Client informed by a memo/letter.
____ (5) Issue a revised report.
____ (6) Sample data is to be reported "as is".
____ (7) Determine the problem in the analytical system.
____ (8) Other (SPECIFY)______________________________

____

CORRECTIVE ACTION TAKEN BY:

Title	Initials	Date	Corrective Action No.
QC Coordinator	____	____	____
Group Leader	____	____	____
QA Manager	____	____	____
Laboratory Director	____	____	____

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APPENDIX A

MODIFICATION 2 TO ORDER 2
STATEMENT OF WORK

9 Jan 92

STATEMENT OF WORK

THE INSTALLATION RESTORATION PROGRAM STAGE 2
FEASIBILITY STUDY (FS) FOR SITE 13
TREATABILITY STUDY FOR SOILS HOLDING AREA
BEALE AFB, CA

I. DESCRIPTION OF WORK

1.1 **Scope.** The objective of the Air Force Installation Restoration Program (IRP) is to assess past hazardous waste disposal and spill sites on Air Force installations and develop remedial actions consistent with the National Contingency Plan (NCP) for those sites which pose a threat to human health and welfare or the environment. The intent is to conduct the remedial investigation and feasibility study in parallel instead of in serial fashion, however, the Beale AFB remedial investigation was completed by a previous contractor and this work effort will perform a feasibility study at IRP site 13. The Installation Restoration Program (IRP) Handbook, Version 3.0, dated May 1990 (mailed under separate cover) is an integral part of this task. All references in this Statement of Work (SOW) to the "Handbook" refer to the above version of the IRP Handbook and imply by reference that it is provided under separate cover. The contractor shall comply with all Handbook requirements. The contractor shall accomplish the following actions at Beale AFB:

a. Develop preliminary alternative remedial actions

~~b. Initial screening of alternatives~~

~~c. Detailed analysis of alternatives~~

~~d. Interim Remedial Design~~

b. Basewide Soil Operations Management Plan

c. Groundwater Monitoring Plan

1.2 **Preliminary Alternative Remedial Actions (FS Phase I).** The contractor shall utilize the data and conclusions obtained from the hydrogeological survey and site characterization to develop preliminary alternative remedial actions for IRP site 13. If preliminary remedial actions were developed during a previous IRP stage, reevaluate the remedial actions selected based on the newly collected data. The required elements for the FS Phase I are provided in the Handbook, Section 3 (Report Format, Section V). Alternatives developed shall include the following categories:

a. Alternatives for on-site treatment and/or disposal

b. Alternatives that attain Applicable or Relevant and

Appropriate Requirements (ARARs)

c. Alternatives that exceed ARARs

d. Alternatives that do not attain ARARs

e. No action

Further, alternatives outside of these categories may also be developed, such as non-cleanup alternatives (e.g., alternate water supply, relocation, etc.). Documentation of the remedial alternative development process, including the decision rationale, shall be provided as an Informal Technical Information Report (ITIR) (Sequence 3, paragraph 6.1) and shall be included in the Feasibility Study Technical Report.

~~1.3 Initial Screening of Alternatives (FS Phase II). The alternatives developed in paragraph 1.2 shall be screened to eliminate those that are clearly infeasible or inappropriate, prior to undertaking detailed evaluation of the remaining alternatives. The required elements for the FS Phase II are provided in the Handbook, Section 3 (Report Format Section V). An ITIR shall be prepared detailing the screening process and identifying the alternatives remaining (Sequence 3, paragraph 6.1). This decision process shall be included in the Feasibility Study Technical Report.~~

~~1.4 Detailed Analysis of Alternatives (FS Phase III). Perform a detailed analysis of the alternatives remaining after the initial screening. the required elements for the FS Phase II are provided in the Handbook, Section 3 (Report Format Section V). Additional guidance can be found in EPA/540/G-85/003, Guidance on Feasibility Studies Under CERCLA. Provide an ITIR describing the analysis procedures, results and conclusions (Sequence 3, paragraph 6.1). The detailed analysis shall include the following:~~

~~a. Technical Analysis~~

~~b. Environmental Analysis~~

~~c. Public Health Analysis~~

~~d. Institutional Analysis~~

~~e. Cost Analysis~~

~~f. Evaluation of Alternatives~~

~~The analysis procedures, decision process, results and conclusions of the detailed analysis shall be included in the Feasibility Study Technical Report.~~

~~1.5 Interim Remedial Design for IRP Site 13~~

~~1.5.1 Design Intent. The design intent shall meet the applicable~~

~~portions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the Superfund Amendments and Reauthorization Act (SARA), the Resource Conservation and Recovery Act (RCRA), the Occupational Safety and Health Act (OSHA), AFR 88-15, and any other state hazardous waste laws and regulations. Use the latest edition of applicable codes and standards available at notice to proceed.~~

~~**1.5.2 Responsibilities.** The Technical Project Manager (TPM) and Contracting Officer's Technical Representative (COTR) for this project are located at HSD/YAQ. The owner of the sites is 814 CES/DEV, Beale AFB, CA. The HSD/YAQ TPM will coordinate the design, development, work directly with the firm, provide guidance and interpret criteria as required, conduct design reviews, obtain necessary approvals, and correspond on all matters within project scope. All contractual matters are the responsibility of the Contracting Officer. If any guidance or review comment is considered beyond the scope of the contract, the firm must notify the COTR to resolve the item in question. Permitting, government supplied equipment and services, and use of government facilities will be coordinated by the TPM with the base.~~

~~**1.5.3 Design Guidance**~~

~~**a. Design Instructions.** HSD/YAQ will provide detailed technical design guidance and the tracking and accountability requirements to assure the best engineering solution is obtained. To accomplish this, the TPM will issue design instructions to the contractor. Design instructions will serve as the design technical basis and quality assurance guidance. Design instructions will be used to clarify any technical issue which arises.~~

~~**b. Confirmation Notices.** To assure accurate communication between the TPM and contractor, the contractor shall provide a record, called a confirmation notice, of all conferences, meetings, discussions, verbal directions, telephone conversations, etc., in which the firm and/or its representatives have participated on matters relative to this project. They are to be numbered sequentially and shall fully identify participants, subject discussed, and any guidance given and/or conclusions reached. Distribution of confirmation notices shall be made within 10 calendar days of the event. Copies shall be sent to the COTR, TPM, and base POC (Sequence 16, paragraph 6.1).~~

~~**1.5.4 Design Submittals.** The intent of the design is to produce a complete set of drawings and specifications using the Corps of Engineers guide plates to allow for a single bid and construction contracting that complies with all applicable federal, state, local, and Department of Defence regulations. Reviews by Air Force and regulatory agency personnel shall be used to assure greatest involvement by all parties. Specification format, drawing organization and contractual provisions will be provided under separate cover. All calculations and specifications shall be on 8 1/2 by 11 paper. Drawings will be on 28 inch by 40 inch mylar. Detailed format will be provided under separate cover to be compatible with Beale AFB contracting. Computer aided design of equal size and title may be substituted provided the drawings are also provided on 5-1/2 inch disk copies. Design of the systems will~~

~~proceed as below. Review by AF will be conducted at each submittal listed below. Additional review by regulatory agency personnel will be conducted at the conceptual design and 90% stages.~~

~~a. Conceptual design. The design shall include a description of a maximum of two (2) feasible technologies for consideration. Provide advantages and disadvantages with a justification for each choice. Additionally, each shall include process schematics, all engineering parameters, boundary conditions, and assumptions used to make the above choices and preliminary cost estimates. The contractor shall make a presentation at Beale AFB describing the design of the selected option (Sequence 9, paragraph 6.1). An outline of the report shall be approved by the TPM and base POC prior to a written report being distributed.~~

~~b. Preliminary working drawings (65% submittal). The contractor shall include outline specifications (double spaced), preliminary plans and updated construction cost estimates of the process selected from the conceptual design (Sequence 20, paragraph 6.1).~~

~~c. Final working drawing (90% submittal). The contractor shall include complete specifications (double spaced), complete plan set, and updated construction cost estimates (Sequence 20, paragraph 6.1).~~

~~d. Final submittal (100% submittal). The contractor shall incorporate all comments and contracting provisions to update the 90% submittal. The final submittal shall be made ready for base contracting to advertise (Sequence 20, paragraph 6.1).~~

1.3 Soil ~~Operations~~ Management Plan.

a. Develop a basewide soil management plan for disposal and treatment of contaminated soils. The contractor shall determine contamination sources, site conditions, clean-up requirements, appropriate clean-up method, schedule of activities, and clean-up costs. Include a discussion of the design, installation and operation of the treatment system. Recommend optimum operating parameters. Provide detailed operating instructions so base personnel can assume responsibility for operation and maintenance. Identify long term and short term recommendations for operation and maintenance. Contractor shall provide a working copy as well as a 1st and 2nd draft of the plan. In this plan, describe the appropriate treatment method and outline a step by step procedure for management of current and future base contaminated soils (Sequence 3, paragraph 6.1).

b. Soil Venting Treatability Study (Soils Holding Area). Install, operate and maintain for one year the Soil Venting treatability study process using the Bio-filter method at the Soils Holding Area as described in the Soil Management Plan.

1. Confirmation Notices. To assure accurate communication between the TPM and contractor, the contractor shall provide a record, called a confirmation notice, of all conferences, meetings, discussions, verbal directions, telephone conversations, etc., in which the firm and/or its representatives have participated on matters relative to this

project. They are to be numbered sequentially and shall fully identify participants, subject discussed, and any guidance given and/or conclusions reached. Distribution of confirmation notices shall be made within 10 calendar days of the event. A maximum of five copies shall be distributed upon coordination with the Technical Project Manager (TPM) (Sequence 16, paragraph 6.1).

2. Soil Venting Treatability Study Submittal. A treatability study submittal shall be prepared detailing the treatability study system for the soils at the soils holding area which provides enough flexibility to process from as little as 500 cubic yards (CY)/year up to 5000 CY/year. The submittal shall be based upon lab analyses as well as permeability and respiration tests previously conducted on the soils. The submittal shall take the following into account: 1) optimal air flow rates to ensure oxygenation of fuel contaminated soils; 2) minimization of hydrocarbon discharge from the biofilter; and 3) optimal nutrient and moisture addition. Submit in a Soils Holding Area Report. The format shall be coordinated with the TPM. (Sequence 16, paragraph 6.1).

3. Soils Holding Area Treatability Study Guidance Manual. Contractor shall prepare and submit a Soils Holding Area Treatability Study Guidance Manual for the system. The manual shall detail what will be required for daily operations and maintenance of the system. Provide training to base personnel as requested by the base POC (a maximum of two 8 hour work days). The format for the Guidance Manual shall be coordinated with TPM (Seq No. 16, para 6.1).

4. Equipment Installation. Based upon the Air Permeability (AP) and In-situ Respiration (ISR) Tests and the design, contractor shall install the required equipment to assure adequate air flow and vacuum for the biofilter system. Equipment shall include electrical wiring, transformers, electric motor with blower, PVC piping for air flow, drain pipe, extraction pipe, nutrient distribution, vapor monitoring points, housing for blower, and a three yard front-end loader. Contractor shall provide a small temporary and portable shelter (not to exceed 8′ x 8′ x 10′) to house the blower unit and associated components. All electrical wiring must conform to base electrical codes. Shelter to house blower must meet all base color and ventilation codes. All equipment except the front-end loader shall become the property of Beale AFB.

5. Operation and Maintenance. Contractor shall perform all major maintenance, repairs, or adjustments to the treatability study system for a one year period. Operate and monitor CO_2, O_2, and hydrocarbon concentrations in the off-gas and the vapor monitoring points (VMPs) every three months. Hydrocarbon concentrations in the off-gas shall conform to local and state requirements. Using a field screening instrument (PID or FID), monitor the surface of the filter pile to determine hydrocarbon breakthrough.

6. In-Situ Respiration Test. Contractor shall perform one ISR test at the end of each six months of continuous operation of the

system (a total of 2 tests).

7. **Reporting.** Contractor shall prepare quarterly Letter Reports (a max of 4 reports with 15 pages max each report) presenting the results of the monitoring, indicating the amount of hydrocarbons which have been biodegraded and volatilized to date, and the results of any ISR tests performed (Sequence 16, para 6.1).

1.4 Site 22-A20 Treatability Study.

a. Contractor shall provide training to base personnel in accordance with the Site 22-A20 Guidance Manual which has been developed of this site (a maximum of two 8 hour days).

b. Contractor shall perform any major maintenance, repairs, or adjustment to the bioventing system at site 22-A20 for a one year period. Contractor shall monitor CO_2, O_2, and hydrocarbon concentrations in the off-gas and the VMPs every three months. Total hydrocarbon concentrations in the off-gas shall be in compliance with local and state requirements.

c. Contractor shall perform one In Situ Respiration (ISR) test at the end of each six months of continuous operation of the bioventing system (a total of 2 tests).

d. Contractor shall prepare quarterly Letter Reports (a maximum of 4 reports with a maximum of 15 pages each) presenting the results of the periodic monitoring, indicating the amount of hydrocarbons which have been biodegraded and volatilized to date, and the results of any ISR test performed (Sequence 16, para 6.1).

1.5 Groundwater Monitoring Plan.

a. The contractor shall prepare a comprehensive groundwater monitoring plan which consists of two rounds of sampling and analysis of groundwater samples from existing base groundwater monitoring wells (Sequence 4, paragraph 6.1). See Annex A, Table 1 for required wells to be sampled. The plan shall consist of a Quality Assurance Project Plan (QAPP) and a Field Sampling Plan (FSP). Prepare a comprehensive groundwater monitoring plan describing how project activities shall be accomplished in the format specified in Section 1 of the Handbook. Include anticipated field work schedule for Round 1 and Round 2 sampling. Include the procedures and locations. Collect and analyze samples according to the parameters listed in Annex B, Tables 1, 2, and 3. Incorporate the findings and data in an ITIR (Sequence 3, paragraph 6.1).

b. **Well Installation.** Drill and install one groundwater monitoring well at ~~IRP~~ Site 8 adjacent to existing well 8-A-1. The well shall be installed at a sufficient depth to collect representative samples of aquifer quality and intercept contaminants that may be floating or stratified in the aquifer. Total footage for this well

shall not exceed two hundred (200) linear feet. Total screening for this well shall not exceed twenty (20) feet. Collect ~~two~~ one groundwater sample. ~~samples, one each sampling round.~~ Analyze for the parameters listed in Annex B. Include sampling results in the same ITIR as listed in paragraph 1.7.a above.

c. **Well Drilling.** Drill the well using air rotary, direct circulation technique. Temporary casings and/or boreholes shall be sufficiently large to provide a minimum of 3-inch annular space on all sides of the well casing and screen during well completion. Ensure wells are installed straight, plumb, and centered in the borehole. Drill and describe the lithology of materials encountered as described for borings in the Handbook. Avoid installing the well in depressions or areas subject to frequent flooding and/or standing water. If the well must be installed in such areas, design the well such that standing water does not leak into the top of the casing or cascade down the annular space.

d. **Well Casing Requirements.** Construct the well with 4-inch inside diameter (I.D.), Schedule 40, PVC casing. Use threaded screw-type joints only. Glued fittings are not permitted. Flush-thread all connections. The well materials shall be certified by the National Sanitation Foundation (NSF) or the American Society for Testing and Materials (ASTM).

e. **Well Screening Requirements.** Screen the well using 4-inch I.D. wire wrap 304 stainless steel screen having up to 0.010 inch openings. Screen opening size may be smaller based upon borehole geology or sieve analysis for the aquifer materials. The well shall be screened across the water table into the upper part of the aquifer (about 20 feet of screen). Screen the well so as to collect floating contaminants and to allow for all yearly fluctuations of the water table. Once the screen is in place, install the sand/gravel pack. If the formation is compatible with the screen opening size, allow the formation to collapse around the well screen. Supplement with washed and bagged, rounded silica sand or gravel with a grain size distribution compatible with screen and the formation. Place the pack from the bottom of the borehole to two (2) feet above the top of the screen. The sand/gravel pack shall not extend into an overlying formation. Tremie a two (2) feet bentonite seal (granulated or pellets) above the sand/gravel pack. The minimum inner diameter of the tremie pipe shall be 1". Ensure that the bentonite forms a complete seal. Tremie grout the remainder of the annulus to the land surface with Type I Portland cement/bentonite slurry. The slurry shall be prepared by adding 3-5 pounds of bentonite and 6.5 gallons of clean water for each 94 pound sack of Type I Portland cement. The bentonite used shall be free of additives that may affect water quality.

f. **Well Completion.** Complete the well using the following specifications:

1. Coordinate with the Base Point of Contact (POC) to determine well completion (flush or projected above the ground surface) requirements.

(a) If well stick-up is of concern in an area, complete the well flush with the land surface. Cut the casing two or three inches below land surface and install a protective locking lid consisting of a cast-iron valve box assembly. Center the lid assembly in a three (3) foot diameter concrete pad sloped away from the valve box. Ensure that free drainage is maintained within the valve box. Also, provide a screw-type casing cap to prevent infiltration of surface water. Maintain a minimum of one (1) foot clearance between the casing top and the bottom of the valve box. Clearly mark the well number on the valve box lid and well casing using an impact labeling method.

(b) If an above-ground-surface completion is used, extend the well casing two or three feet above land surface. Provide an end plug or casing cap for the well. Shield the extended casing with a steel guard pipe (sleeve) which is placed over the casing and cap and seated in a two-foot by two-foot by four-inch (2′ X 2′ X 4") concrete surface pad. Slope the pad away from the well sleeve. Install a lockable cap or lid on the guard pipe. Install three (3) three-inch (3") diameter concrete-filled steel guard posts if the base POC determines that the well is in an area which needs such protection. The guard posts shall be five (5) feet in total length and installed radially from each wellhead. Recess the guard posts approximately two (2) feet into the ground and set in concrete. Do not install the guard posts in the concrete pad placed at the well base. Fill each guard post with concrete. Clearly mark the well number on the well protective sleeve exterior using paint and/or impact lettering. The base POC will specify color to blend with the paint scheme of the base.

(c) The well shall be secured as soon as possible after drilling. Provide corrosion resistant locks for both flush and above-ground well assemblies. The locks shall either have identical keys or be keyed for opening with one master key. Turn the keys over to the base POC following completion of the field effort.

(d) Well Logs. Prepare a well completion log and schematic diagram showing well construction details. Lithologic descriptions and other information shall be included in the well logs.

2. Well Development.

(a) Develop the well as soon as practical after well completion and grout curing with a submersible pump, bailer, vented surge block, and/or airlift method. Continue well development until the discharge water is clear and free of sediment to the fullest extent possible. Measure the rate of water production, pH, specific conductance, and water temperature during well development and include this information in the ITIR (paragraph 1.7.a).

(b) Following well development and after water levels have stabilized, the water-yielding properties of each well shall be determined. Each new well shall be pumped, using a submersible pump, and the discharge and drawdown measured for a period of 1 to 4 hours. Using the discharge and drawdown data, compute the specific capacity.

(c) Water Level Measurements. Measure water levels at all test wells as feet below the measuring point elevation (usually top of casing) to the nearest 0.01 foot. Report as feet above mean sea level (MSL). Measure static water levels in the well prior to well development and before all well purging preceding sampling events.

(d) Before each water sampling event, measure water levels at all wells within an 8-hour period for the construction of a base-wide potentiometric contour map. In addition, the contractor shall record water levels before well purging and after sampling of each well.

~~1.8 Reports~~

~~1.8.1 Feasibility Study Technical Report. Use the findings from the IRP Stage 2 Remedial Investigation Report to prepare a feasibility Study Technical Report. Integrate all investigative work done at Site 13 to date so that the report evaluates the total cumulative information for the site. This report shall include a detailed discussion of the recommended alternative remedial actions (Sequence 4, paragraph 6.1).~~

~~1.8.2 Draft Reports. Draft reports are considered "draft" only in the sense that they have not been reviewed and approved by the Air Force. In all other respects, "drafts" must be complete, in the proper format, and free of grammatical and typographical errors. All draft reports shall be thoroughly screened through in-house peer technical review before being released to HSD/YAQ.~~

~~1.8.3 Report Format. Strictly adhere to HSD/YAQ format (IRP Handbook, Section 3) for preparation of draft and final reports. This format is an integral part of this delivery order.~~

1.6 Special Notifications. Immediately report to the ~~HSD/YAQ~~ TPM or his/her supervisor, via telephone, any data/results generated during this investigation which may indicate an imminent health risk. Follow the telephone notification with a written notice within three (3) days and attach a copy of the raw laboratory data (e.g., chromatograms, standards used for calibration, etc.) (Sequence 16, paragraph 6.1).

1.7 R & D Status Reports. Include all data as required by the IRP Handbook, Section 6. Tabulated field and laboratory test results and QA/QC data shall be incorporated into the next monthly R & D Status Report as they become available and forward to ~~HSD/YAQ~~ Air Force Center for Environmental Excellence (AFCEE) (Sequence 1, paragraph 6.1).

1.8 Variations. The above technical efforts, which include maximum requirements, are estimates only. Should the contractor determine technical efforts, including field work, require variation from these estimates, the contractor shall obtain a written concurrence from the contracting officer's technical representative at ~~HSD/YAQ~~ AFCEE. This concurrence is required prior to proceeding with the variation. Under such circumstances, the ceiling price of this order shall remain unchanged. Should an increase in the ceiling amount be necessary, contracting officer authorization will be required prior to proceeding with the variation.

II. SITE LOCATION AND DATES:

Beale AFB, CA
Date to be established

III. BASE SUPPORT

The base will:

3.1 Provide IRP contractor personnel with an initial facility tour to familiarize them with the facility and IRP sites covered under this contract.

3.2 Locate underground utilities and issue digging or other appropriate permits to the IRP contractor prior to the commencement of digging or drilling operations.

3.3 Provide the following:

a. Provide the contractor with copies of existing engineering plans, drawings, diagrams, aerial photographs, digitized map files, etc., to facilitate evaluation of IRP sites under investigation.

b. Provide a copy of base electrical, color, and ventilation codes to facilitate the studies at Site 22-A20 and the soils holding area. Provide separate copy of a base map for the contractor to prepare marked drawings showing the locations of all tank leak sites.

c. Provide personnel to perform routine operational maintenance evaluations on electrical blower units at treatability study sites.

3.4 Arrange for the following:

a. Personnel identification badges, vehicle passes, and/or entry permits.

b. A dedicated storage area (approximately 1000 square feet) for storing equipment and supplies.

c. A supply (e.g., fire hydrant, stand pipe, etc.) of large quantities of potable water for equipment cleaning, etc.

d. Electrical power source to operate blowers at the treatability study sites until bioremediation systems are dismantled.

e. A paved area where drilling equipment can be cleaned and decontaminated. A source of potable water (i.e., ordinary outdoor water faucet) and a 110/115 VAC electrical outlet will be available within 100 feet of the paved area for steam cleaner hook-up. Drainage from this paved area will be through an oil/water separator to a sanitary sewer. It will be the contractor's responsibility to ensure that the sediment trap and oil/water separator is kept clean of sediment from the washing of their vehicles. The contractor will also be responsible to

coordinate with the base the use of any detergents that will be discharged to the sanitary sewer.

f. A set of keys to the locks on groundwater monitoring wells.

IV. GOVERNMENT FURNISHED PROPERTY: None

V. POINTS OF CONTACT:

5.1 Modern Technologies Corporation
Technical Project Assistant (TPA)
Ms Sharon R. Hrabovsky
(512) 927-4300
Voice Mail: 1-800-821-4528, ext 315

5.2 **Base Point of Contact (POC)**
Mr. Kirk Schmalz
814 CSG/DEV
Beale AFB, CA 95903-5000
AV 368-2642
(916) 634-2642

5.3 Base Point of Contact
Mr. Thomas Hultin
814 CSG/DEV
Beale AFB, CA 95903-5000
AV 368-2642
(916) 634-2642

5.4 Contr. Officer's Tech Rep (COTR)/
Technical Project Manager (TPM)
Capt. Mark E. Smallwood
AFCEE/ESRT
Brooks AFB, TX 78235-5000
(512) 536-9001, ext 238
AV 240-9001, ext 238
1-800-821-4528, ext 238

VI. DELIVERABLES

6.1 Attachment 1 of the basic contract. In addition to Sequence Numbers 1 and 5 listed in Attachment 1 to the basic contract which apply to all orders, the Sequence Numbers and dates listed below are applicable to this order:

SEQUENCE NUMBER	PARA NO.	BLOCK 10 FREQUENCY	BLOCK 11 AS OF DATE	BLOCK 12 DATE OF 1ST SUB.	BLOCK 13 DATE OF 2ND SUB	BLOCK 14 # OF COPIES
3 (ITIR - Prelim RA)	I.1.2	OTIME	90 Sep 13	90 Nov 15	–	4
~~3 (ITIR - Screen of RAs)~~	~~I.1.3~~	~~OTIME~~	~~90 Sep 13~~	~~91 Feb 28~~	–	~~4~~
~~3 (ITIR - Det. Anal of RAs)~~	~~I.1.4~~	~~OTIME~~	~~90 Sep 16~~	~~91 Apr 15~~	–	~~4~~
~~9 (Con Design/Proc. Mat'l)~~	~~I.1.5.4a~~	~~OTIME~~	~~90 Nov 03~~	~~91 Apr 15~~	–	~~2~~
~~20 (65% Design)~~	~~I.1.5.4b~~	~~OTIME~~	~~91 Apr 15~~	~~91 May 24~~	–	~~10~~
~~20 (90% Design)~~	~~I.1.5.4c~~	~~ONE/R~~	~~91 Apr 15~~	~~91 Jul 08~~	~~91 Aug 01~~	~~10~~
~~20 (100% Design)~~	~~I.1.5.4d~~	~~OTIME~~	~~91 Apr 15~~	~~91 Aug 30~~	–	~~10~~
~~16 (Conference Notices)~~	~~I.1.5.3b~~	~~ASREQ~~	~~91 Apr 15~~	~~91 Aug 20~~	–	~~5~~
3 (Soil Management Plan)	I.1.3a	ONE/R	90 Sep 13	91 Apr 24	91 Jun 10	a
16 (Soils Holding Area Report)	I.1.3b.2	ONE/R	91 Dec 15	92 Feb 15	92 Apr 02	5
16 (Confirmation Notices)	I.1.3.b1	ASREQ	91 Dec 15	c	–	5
16 (Soils Holding Area Guidance Manual)	I.1.3.b3	ONE/R	91 Dec 15	92 Apr 15	–	3
16 (Quarterly Letter Rpt)	I.1.3.b7	OTIME	91 Dec 15	d	d	d
16 (Quarterly Letter Rpt)	I.1.4.d	ONE/R	91 Dec 15	d	d	d
4 (GW Monitoring Plan)	I.1.5a	ONE/R	90 Sep 13	90 Nov 30	91 Apr 24	10
3 (ITIR - Groundwater Data)	I.1.5a	OTIME	91 Apr 24	91 Jun 28	–	10
~~4 (FS Technical Report)~~	~~I.1.8.1~~	~~ONE/R~~	~~92 Apr 28~~	~~91 Jul 25~~	~~92 Sep 23~~	~~a~~
16 (Special Notification)	I.1.6	OTIME	b	b	–	3

6.2 Notes

a. Working copy, first draft, second draft (7 copies each) and one final report (10 copies plus the original camera-ready copy) are required. Incorporate Air Force comments into the final report as specified by the TPM. Supply the TPM and base POC with an advance copy prior to distribution. Distribute the remaining copies as specified by the TPM.

b. Provide written notice with supporting documentation within three days of telephone notification and at the direction of the TPM. Assume a maximum of 100 pages.

c. Provide confirmation notices within 7 days.

d. Provide the quarterly monitoring letter report within 30 days of quarterly monitoring. Provide 5 copies and distribute as specified by the TPM.

ANNEX A, TABLE 1 GROUNDWATER SAMPLING WELLS

SITE	WELL NAME
1	1-C-1
	1-A-1
	1-C-2
	1-C-3
	1-C-4
	1-C-5
2	2-R-1
	2-R-2
	2-R-3
	2-R-4
	2-A-1
	2-C-1
3	3-A-1
	3-A-2
	3-A-3
	3-A-4
	3-A-5
	3-C-1
4	4-A-1
5	5-A-1
	5-C-1
6	6-A-1
	6-A-2
	6-C-1
8	NEW WELL, NAME 8-E-1
10	10-A-1
11	11-A-1
13	13-A-1
	13-A-2
	13-C-1
	13-C-2
	13-C-3
	13-C-4
	13-C-5
	13-C-6
15	15-A-1
	15-A-2
	15-A-3
	15-A-4
16	16-C-1
18	18-C-1
	18-C-2
19	19-C-1
	19-C-2
	19-C-3
	19-C-4
21	21-C-1
23	23-C-1
BACKGROUND	BG-C-1
	BG-C-2
OFFBASE	AMBROSIO DOMESTIC WELL
	AMBROSIO AGRICULTURE WELL

Annex B, Table 1B
Analytical Methods for 1st Round Groundwater Samples

PARAMETER	ANALYT METHOD	#1	#2	#3	#4	#5	#6	#8	#10	#11	#13	#15	#16	#18	#19	#21	#23	BKGR	OFF-SITE	TOT
Purgeable Halocarbons	SW5030/ SW8010	6	6	–	–	2	–	1	1	–	8	–	–	–	4	–	1	2	2	33
Purgeable Aromatics	SW5030/ SW8020	6	6	6	–	–	3	1	1	1	8	–	–	2	4	–	1	2	–	41
Semivolatile Organic Compounds	SW3550/ SW8270	–	6	6	–	–	3	1	1	–	8	4	–	–	–	–	–	2	–	31
Arsenic	SW3020/																			
Total Recoverable	SW7060	–	6	6	–	–	–	–	–	–	–	4	1	–	–	–	–	2	–	19
Dissolved		–	6	6	–	–	–	–	–	–	–	4	1	–	–	–	–	2	–	19
Lead	SW3005/																			
Total Recoverable	SW7421	–	6	–	1	–	–	–	–	–	8	–	–	–	4	–	–	2	–	21
Dissolved		–	6	–	1	–	–	–	–	–	8	–	–	–	4	–	–	2	–	21
Mercury	SW7470																			
Total Recoverable		–	6	–	–	–	–	–	–	–	8	–	–	–	–	–	–	2	–	16
Dissolved		–	6	–	–	–	–	–	–	–	8	–	–	–	–	–	–	2	–	16
Zinc (Total)	SW3050/ SW6010	6	6	6	–	2	–	–	–	–	8	4	–	2	4	1	–	2	–	41
Cyanide (Total)	SW9010	–	6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6
Total Fuel Hydrocarbons	SW8015	–	–	6	–	–	–	–	1	–	–	–	–	2	–	1	1	2	–	13
Nickel	SW3050/																			
Total Recoverable	SW6010	6	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	2	–	10
Dissolved		6	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	2	–	10
Dioxin	SW8280	–	6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	8
Hexavalent Chromium	SW7196	–	6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6

Annex B, Table 2A
Analytical Methods for 2nd Round Groundwater Samples

PARAMETER	ANALYT METHODS	#1	#2	#3	#4	#5	#6	#8	#10	#11	#13	#15	#16	#18	#19	BKGR	OFF-SITE	TOTAL
Purgeable Halocarbons	SW5030/ SW8010	6	–	–	–	–	–	1	–	–	8	–	–	–	–	–	3	18
Purgeable Aromatics	SW5030/ SW8020	6	–	–	–	–	–	1	–	–	8	–	–	–	–	–	–	15
Semivolatile Organic Compounds	SW3550/ SW8270	–	–	–	–	–	–	1	–	–	8	–	–	–	–	–	–	9
Mercury	SW7470																	
Total Recoverable		–	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8
Dissolved		–	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8
Lead	SW3005/ SW7421																	
Total Recoverable		–	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8
Dissolved		–	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8

Annex B, Table 3B
Analytical Methods and Total Number of Water Analyses

PARAMETER	ANALYTICAL METHOD	REPORTING UNITS	NUMBER OF ANALYSES	TRIP BLANKS	AMB COND BLANKS	EQUIP BLANKS	DUP/REP	SECOND COLUMN	TOTAL ANALYSES
Purgeable Halocarbons	SW5030/SW8010	µg/L	51	11	1	8	6	32	109
Purgeable Aromatics	SW5030/SW8020	µg/L	56	11	1	8	6	35	117
Semivolatile Organic Compounds	SW3550/SW8270	µg/L	40	–	–	7	4	–	51
Arsenic	SW3020/SW7060	mg/L							
Total Recoverable			19	–	–	2	2	–	23
Dissolved			19	–	–	2	2	–	23
Lead	SW3005/SW7421	mg/L							
Total Recoverable			29	–	–	6	3	–	38
Dissolved			29	–	–	6	3	–	38
Mercury	SW7470	mg/L							
Total Recoverable			24	–	–	5	3	–	32
Dissolved			24	–	–	5	3	–	32
Zinc (Total)	SW3050/SW6010	mg/L	41	–	–	5	5	–	51
Cyanide (Total)	SW9010	mg/L	6	–	–	3	1	–	10
Total Fuel Hydrocarbons	SW8015	mg/L	13	–	–	1	1	–	15
Nickel	SW3050/SW6010	mg/L							
Total Recoverable			10	–	–	1	1	–	12
Dissolved			10	–	–	1	1	–	12
Dioxin	SW8280	µg/L	8	–	–	1	1	–	10
Hexavalent Chromium	SW7196	mg/L	6	–	–	1	1	–	8

APPENDIX D

HEALTH AND SAFETY PLAN

HEALTH AND SAFETY PLAN
Environmental Restoration Projects
TPH Soil Treatment
BEALE AIR FORCE BASE, CALIFORNIA

Prepared for

Air Force Center for Environmental Excellence
Brooks Air Force Base, Texas 78235-5000

April 1993

Prepared by

ENGINEERING-SCIENCE, INC.
DESIGN • RESEARCH • PLANNING
1301 MARINA VILLAGE PARKWAY, ALAMEDA, CA 94501 • 510/769-0100
OFFICES IN PRINCIPAL CITIES
NC289/35-34

HEALTH AND SAFETY PLAN

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USAF Contract No. F33615-90-D-4014
Order No. 2, Modification 2

ENVIRONMENTAL RESTORATION PROJECTS

AT

BEALE AIR FORCE BASE
YUBA COUNTY, CALIFORNIA

NC289

HEALTH AND SAFETY PLAN

April 1993

Prepared by:

Michael Phelps, Project Health and Safety Officer	4/8/93 Date
Diane Spencer, Project Team Member	April 7, 1993 Date
Eric Storrs, Alternate Project Health and Safety Officer	4/8/93 Date

Reviewed and approved by:

Richard Makdisi, Project Manager	4/8/93 Date
Dennis Brown Office Health and Safety Representative	4/7/93 Date

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EMERGENCY CONTACTS

In the event of any situation or unplanned occurrence requiring outside assistance or support services, the appropriate contact(s) from the list below should be made. The nearest public telephone to the site can be found at the gasoline service station located at the intersection of Warren Shingle Blvd. and J Street.

• Emergency Fire/Police or Medical	911
• Beale AFB Non-emergency Fire	(916) 634-8675
• Beale AFB Non-emergency Police	(916) 634-2131
• Poison Control Center	(800) 523-2222
• Chem-trec	(800) 424-9300
• **Beale AFB Hospital Warren Shingle Boulevard Beale AFB**	**(916) 634-2992**

Directions to emergency room nearest site: The emergency room at Beale AFB Hospital is located on a cul de sac on the north side of Warren Shingle Boulevard approximately 5 miles east of the contaminated soil treatment area. The location of the hospital is shown on Figure 2, page 4.

Engineering-Science Contacts

Phil Storrs
Corporate Health and Safety Manager
ES Pasadena, California
(818) 440-6000

Richard Makdisi
Project Manager
ES Alameda, California
(510) 769-0100

Edward Grunwald
Deputy Corporate Health and Safety Manager
ES Atlanta, Georgia
(404) 325-0770

Dennis Brown
Office Health and Safety Representative
ES Alameda, California
(510) 769-0100

Client Contacts

Ms. Sheri Rolfsness
Base Point of Contact (POC)
Beale AFB
(916) 634-2642

Capt. John Coho
Technical Project Manager (TPM)
Brooks Air Force Base
(800) 821-4528

ENVIRONMENTAL RESTORATION PROJECTS

AT

BEALE AIR FORCE BASE
YUBA COUNTY, CALIFORNIA

HEALTH AND SAFETY PLAN

1.0 INTRODUCTION

This Health and Safety Plan should be used as a guide to aid the project manager in making health and safety decisions during field activities at Beale AFB. This Plan should also be used as a primary source of information on health and safety matters by all site personnel. The Project Health & Safety Officer or his designee will conduct a brief "tailgate" Health & Safety meeting at the site with individuals new to the site, to introduce them to site specific Health & Safety concerns. The Plan Acceptance Form (Appendix A) will be filled out by each individual attending the tailgate H&S meeting. In addition to initial tailgate Health and Safety meetings, the Project Health and Safety Officer or his designee will conduct brief weekly Health and Safety tailgate meetings to reaffirm Health and Safety procedures to be used during site activities.

Purpose

The purpose of this plan is to establish personnel protection standards and mandatory safety practices and procedures. This plan assigns responsibilities, establishes standard operating procedures, and provides for contingencies that may arise during site activities.

Applicability

The provisions of this plan are mandatory for all on-site tasks. All ES personnel shall abide by this plan. The ES Project Manager shall provide copies of this plan to subcontractors to ES, informing them of potential health and safety risks associated with this site. This plan does not cover subcontractors or their employees. Subcontractors are required to prepare their own Health and Safety Plan in compliance with OSHA 29 CFR 1910.120 and any other applicable regulatory requirements. Subcontractors are required to comply with all regulatory requirements and are fully responsible for health and safety of their own employees.

Site Description

The project site is located in Yuba County between the Bear and Yuba Rivers, 10 miles east of Marysville, California. Beale Air Force Base is approximately 40 miles north of Sacramento and 130 miles northeast of San Francisco, California. The base is

comprised of approximately 22,944 acres of land in the Sacramento Valley and the lower foothills of the Sierra Nevada (Figure 1).

2.0 PROJECT DESCRIPTION

The Beale Air Force Base Site Project is part of the Air Force Installation Restoration Program (IRP) for which ES is under contract with the Air Force Center for Environmental Excellence (AFCEE). This contract is a multi-task contract. The Beale AFB project described here is work Order 02, Modification 02. Modification 02 consists of two main components or subprojects: the surface bioventing treatability study and the one year operation of the 22-A20 site *in-situ* bioventing project. Figures 2 and 3 show 22-A20 site and the Beale area surface bioventing site.

Surface Bioventing Site

The current "soils holding area" at Beale AFB is the location of the surface bioventing project which entails preparation of an existing pad which will be used for the treatment of TPH contaminated soil by bioventing assisted by air supplied through a blower. The pad preparation, which will be completed by an ES selected subcontractor based on a bid package prepared by ES, will focus primarily on sealing the concrete seams, berming the pad, preparing ramps, etc. After pad preparation, an initial 150 cubic yard cell from the holding area will be laid out on the new pad and a pilot test on this "bioventing cell" will be performed by ES to assure the viability of the technology before adding up to eight (8) additional 150-cubic yard biocells on the pad for treatment. The vapor stream from the blower will be vented through a "clean" biofilter to facilitate the biodegradation of the sorbed TPH.

ES will be responsible for the operation and maintenance and quarterly testing and assessment of the soil treatment pad for a one year period. After the completion of a year of monitoring, ES will complete a summary treatability study report to evaluate the treatment system viability.

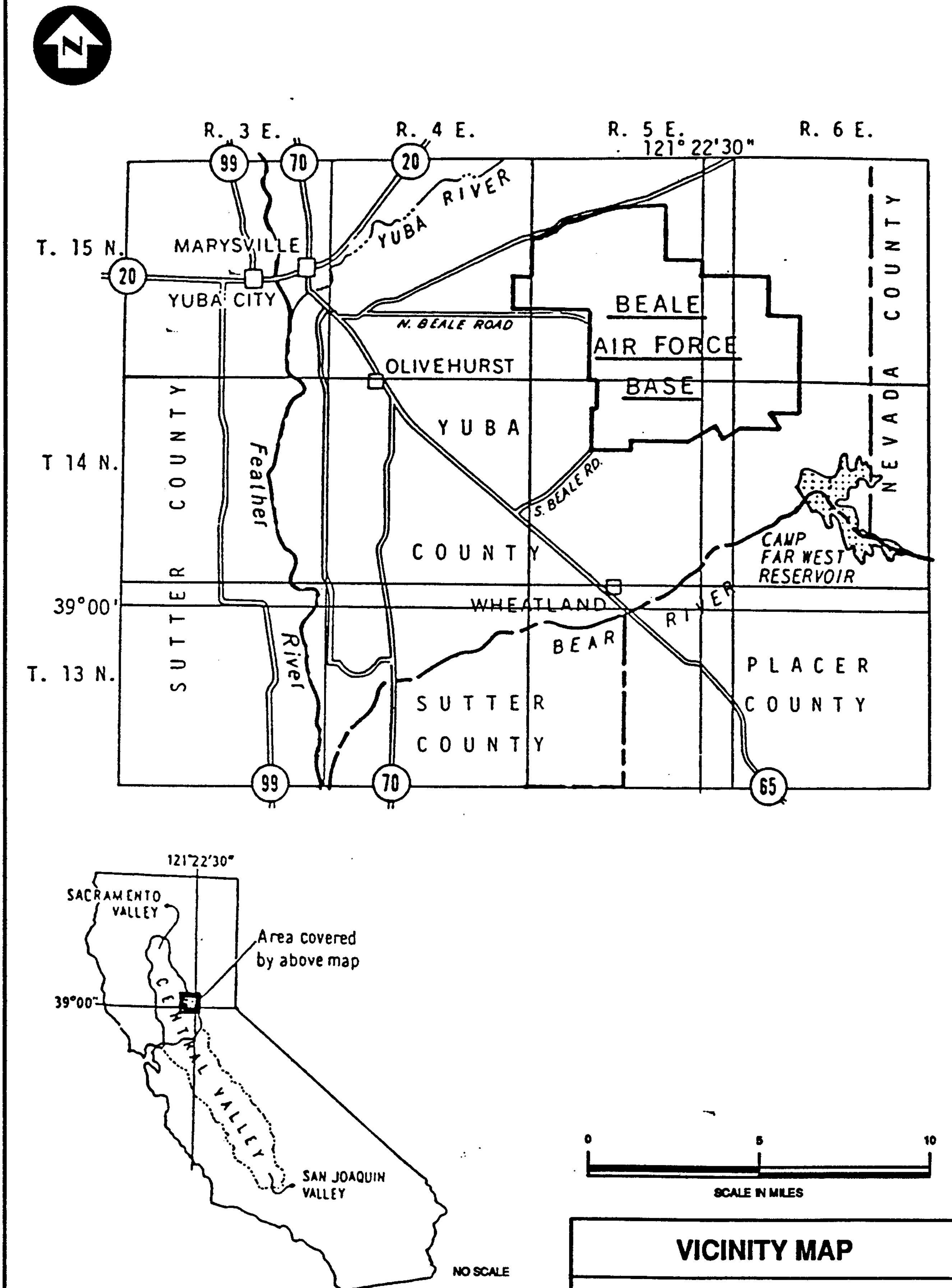
22-A20 Site

Site 22-A20 is the location of a bioventing system already designed, tested and installed by ES. This system was installed in August 1992 at the location of a former underground fuel storage tank that had leaked substantive TPH contamination into the soil at depths and locations which made the full excavation of the TPH contaminated soil impractical. This modification 02 covers the O&M of this bioventing system for a one year period and includes quarterly monitoring to measure O_2, CO_2, VOCs and respiration in order to assess the rate of TPH degradation. A final report after a year of monitoring will be completed.

Scope of Work

The modified delivery Order (Order 02/Modification 02) includes: 1) the completion of a treatability study for a surface bioventing system to treat TPH contaminated soil; and 2) one year of operation and maintenance of the *in situ* bioventing system at UST Site 22-A20 adjacent to Building 2171.

FIGURE 1



SOURCE: GROUNDWATER CONDITIONS AT BEALE AIR FORCE BASE AND VICINITY, CALIFORNIA. U.S. GEOLOGICAL SURVEY OPEN-FILE REPORT 80-204, PAGE, 1980

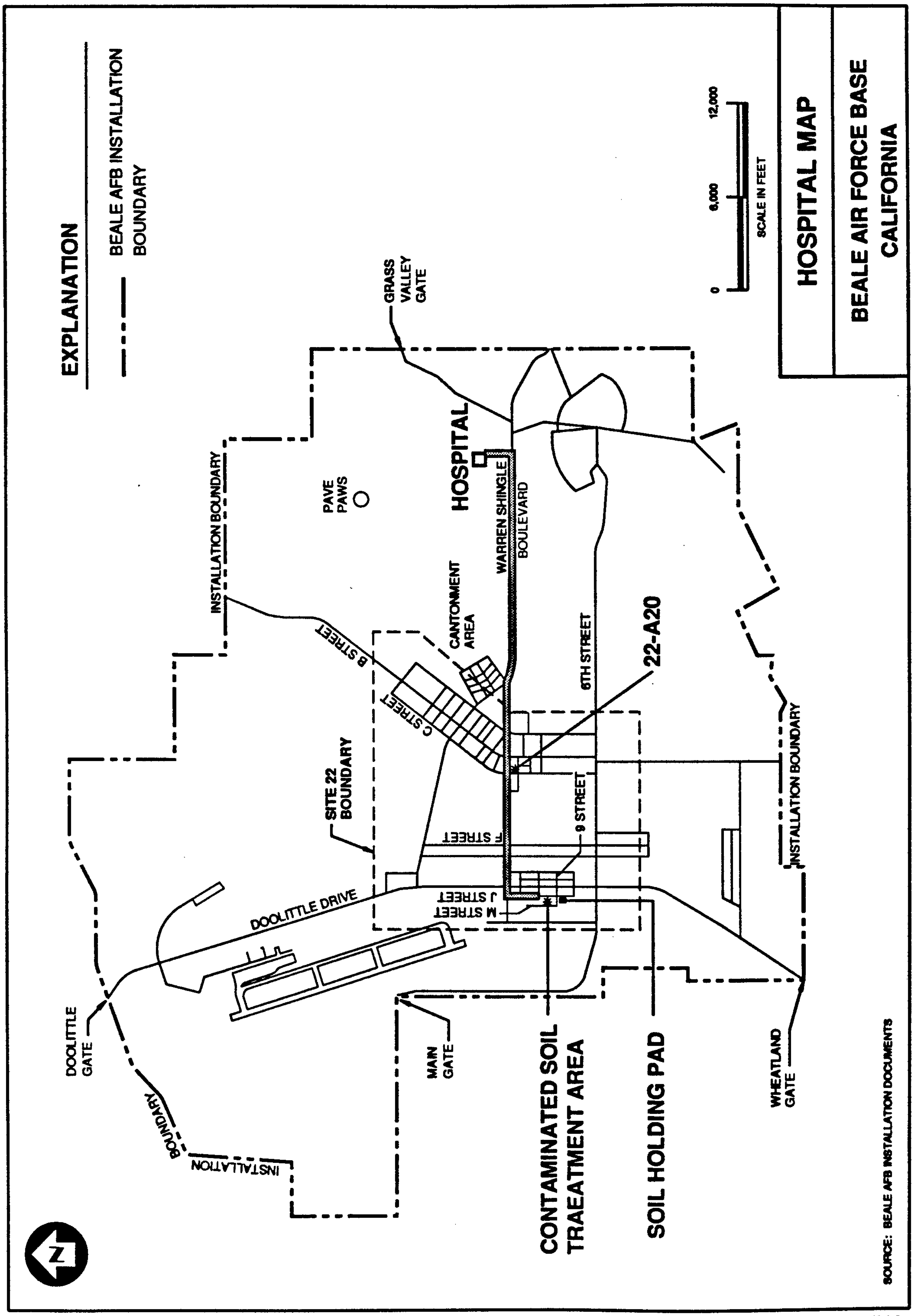
VICINITY MAP

BEALE AIR FORCE BASE
CALIFORNIA

REV. 1 C251-01.DWG 03/08/93

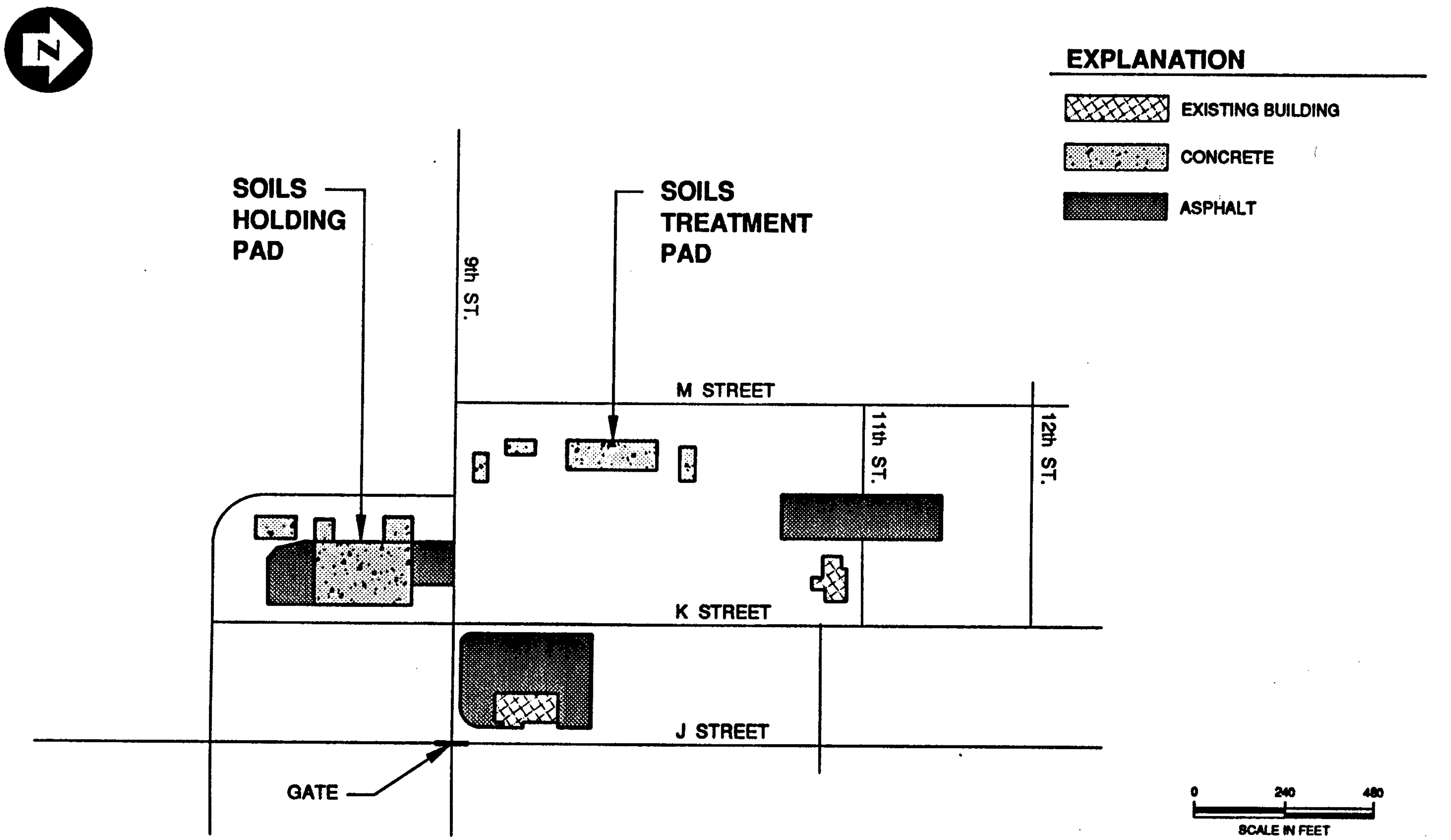
ENGINEERING-SCIENCE, INC.

FIGURE 2



REV. 1 C252-02.DWG 04/06/93

ENGINEERING-SCIENCE, INC.



CONTAMINATED SOILS TREATMENT AREA

BEALE AIR FORCE BASE CALIFORNIA

FIGURE 3

REV. 1 C251-03.DWG 03/08/93

Specific on-site field activities covered by this Health and Safety Plan include:

- 150 Cubic Yard Pilot Test
- Equipment installation
- *In situ* respiration test
- Training of base personnel for Site 22-A20
- Operation and maintenance for Site 22-A20
- *In situ* respiration test for Site 22-A20

3.0 PROJECT TEAM ORGANIZATION

Project Manager:	Richard Makdisi
Principal Engineer:	Diane Spencer
Project Health and Safety Officer:	Michael Phelps
Project Health and Safety Officer - Alternate:	Eric Storrs
Project Team Members:	Eric Storrs, Fred Stanin, Michael Phelps, Henry Pietropaoli

Included in Appendix B is a description of the responsibilities and work procedures of each of the project team members.

4.0 SITE-SPECIFIC EMPLOYEE TRAINING AND MEDICAL MONITORING REQUIREMENTS

All project team members and ES subcontractors involved in field operations must be able to provide documentation that they have received OSHA 40-hour health-and-safety training meeting the requirements of 29 CFR 1910.120, Paragraph E. All project team members and subcontractors must have completed an 8-hour refresher training course during the past 12 months if the 40-hour training course was received prior to the past 12 months. In addition, site workers working unsupervised on site must have received 3 days prior field experience in the specific field operations performed under the direct supervision of a trained and experienced supervisor. Field team members must also have completed a course in emergency first aid/CPR prior to coming on site.

In addition to the above training requirements, the field team leader must have completed an 8-hour Supervisory training course (29 CFR 1910.120).

All project team members and ES subcontractors working on site must be enrolled in a medical monitoring program, and must have had a medical monitoring exam within the previous 12 months. A further description of medical monitoring requirements is included in Appendix C.

5.0 HEALTH AND SAFETY RISK ANALYSIS

Introduction

The potential exists for chemical exposure, occupational injury and/or environmental stress at the project site. These hazards are covered in the following sections. Table 1

summarizes the soil profile of excavated soils contaminated with TPH. This profile is typical of soils encountered as part of the Scope of Work. A discussion of the properties and potential health and safety concerns associated with exposure to contaminant compounds is presented in Appendix D. A summary of the personal protective equipment required to minimize chemical exposure is presented in the personal protection section of the text (Section 6.0). The Project Health and Safety Officer should inform site personnel of the hazards associated with these chemical compounds at the tailgate Health and Safety meeting(s).

Chemical Hazards

Chemical compounds have either been identified in stockpiled soils at the project site (those listed in Table 1), or may be anticipated to exist in site soils on the basis of historical site research.

The properties and potential health hazards associated with these contaminants are listed in Table 2. Appendix D summarizes overall chemical and hazards associated with the major groups of contaminants.

The potential for chemical exposure may be present during all phases of site activity, but might especially occur during soil relocation and vapor venting activities. A summary of the personal protective equipment required to minimize chemical exposure is presented in the personal protection section of the text.

Safety Hazards

Safety hazards consist of accidents that can occur during operation of heavy equipment (trucks, loaders, tractors, discs, etc.), while installing pipes and instruments, loading and unloading the blower, handling of sharp tools (knives, etc.), and other accidents resulting from falls. A front loader will be used to move soil from the soil holding pad to the treatment pad. A truck or a front loader will be used to transport soil for the biofilter. A drilling rig or similar will be used for installing wells for the *in situ* bioventing project. Engineering-Science personnel will not be operating heavy equipment and specific directions to equipment operators will be done by contractors responsible for the equipment. Potential for these types of accidents must be minimized by the use of proper safety equipment (hard hat, steel-toed boots, safety glasses), good communication among all on-site personnel, and by being alert to potential hazards.

Noise

The Project Health & Safety Officer and the ES field supervisor will observe the on-site work and determine if noise appears to be excessive. Should it be determined that excessive noise is being created due to an on-site operation, a review of the process will be undertaken to reduce, if possible, ambient noise levels. Earplugs will be available at the site at all times for personnel protection.

Heat Stress

Depending on temperature, humidity, wind speed, individual acclimatization, and the duration of site work to be performed, monitoring for heat stress may be necessary.

TABLE 1
TPH CONTAMINATION
SOIL HOLDING PAD, BEALE AFB

Site	# of Collected Collected	Soil Volume (a) (a)	Soil Chemistry in $\mu g/kg$ TPH Range	TPH Diesel 8015 (Max)	TPH Gasoline 8015 (Max)	TPH 418.1 (Max)	Benzene (Max)	Toluene (Max)	Ethyl Benzene (Max)	Xylenes (total) (Max)	Date of Excavation
250	3	5	ND–54,000	5,700	NA	54,000	ND	ND	ND	ND	June 1992
355	6	10	ND–310,000	310,000	NA	15,000	ND	ND	6.8	40	May 1992
440	4	5	ND–46,000	ND	NA	46,000	ND	ND	ND	ND	May 1992
469	4	10	ND–94,000	ND	NA	94,000	ND	ND	ND	ND	May 1992
502	7	15	83,000–2,400,000	240,000	NA	2,400,000	ND	ND	ND	6.2	May 1992
510	4	5	ND–780,000	ND	NA	780,000	ND	ND	ND	ND	May 1992
815	2	5	n.a.	ND	NA	ND	ND	ND	ND	ND	July 1992
1023	2	15	8,000–250,000	250,000	NA	NA	ND	ND	ND	ND	June 1992
1027	6	2,000	4,100–6,700,00	6,700,000	6,500,000	16,000	3,100	3,900	17,000	13000	June/Sept. 1992
1029	2	5	17,000–59,000	59,000	NA	NA	ND	ND	ND	ND	June 1992
1060	2	5	320,000–470,000	470,000	NA	NA	ND	ND	6	45	July 1992
1071	3	5	ND–180,000	180,000	NA	110,000	ND	ND	ND	21	July 1992
1073	1	5	n.a.	ND	NA	NA	ND	ND	ND	ND	July 1992
1077	3	5	140,000–1,000,000	1,000,000	NA	40,000	23	ND	17	50	June 1992
1086	4	15	n.a.	ND	NA	ND	ND	ND	ND	ND	June 1992
1225	16	2000	ND–6,000,000	6,000,000	860,000	84,000	48,000	190,000	83,000	400,000	June 1992
1230	2	5	1,300,000–6,900,000	6,900,000	NA	NA	870	2300	550	3200	June 1992
1240	2	10	170,000–220,000	220,000	NA	NA	ND	ND	50	190	June 1992
1243	4	5	ND–15,000	ND	NA	15,000	ND	ND	ND	ND	June 1992
1319	2	15	37,000–260,000	260,000	NA	NA	ND	ND	ND	ND	July 1992
1320	3	10	3,500–26,000	14,000	NA	26,000	ND	ND	440	1400	June 1992
1322	3	10	2,300–7,800	7,800	NA	NA	ND	ND	ND	ND	NR
JT–1	1	NR	n.a.	6,200	NA	NA	ND	ND	ND	11	April 1992
JT–2	1	NR	n.a.	77,000(b)	NA	NA	ND	ND	ND	ND	April 1992
2161	6	5	ND–2,400,000	2,400,000	NA	2,400,000	ND	9.4	ND	21	May 1992
2172	5	5	36,000–740,000	120,000	NA	740,000	ND	ND	ND	7.7	June 1992
2415	1	0	n.a.	ND	NA	NA	ND	ND	ND	ND	April 1992
2417	3	10	ND–7,200,00	57,000	NA	7,200,000	ND	ND	ND	15	April 1992
2419	2	0	94,000–1,200,000	1,200,000	190,000	NA	ND(c)	710	330	1,800	April 1992
2420	6	10	6,800,000–3,800,000	3,800,000	NA	180,000	120	830	2,000	11,000	April 1992
2431	4	5	ND–1,100,000	1,100,000	NA	460,000	8.7	7.6	ND	9.8	April 1992
2432.1	4	20	n.a.	ND	NA	74,000	ND	ND	ND	ND	April 1992
2432.2	3	5	ND–22,000	ND	NA	22,000	ND	ND	ND	ND	April 1992
2435	2	5	n.a.	ND	NA	NA	ND	ND	ND	ND	June 1992
2439	3	5	4,500–8,200	8,200	NA	59,000	ND	ND	ND	ND	April 1992
2442	4	5	17,000–75,000	75,000	NA	22,000	ND	2.7	21	99	May 1992
2444	4	5	ND–53,000	9,700	NA	53,000	ND	ND	ND	ND	May 1992
2446	5	5	ND–310,000	ND	NA	310,000	ND	ND	ND	ND	May 1992
2453.1	9	25	ND–1,500,000	1,500,000	NA	1,000,000	6.8	640	1,200	3,300	April 1992
2453.2	4	25	ND–1,800,000	1,800,000	NA	1,100,000	730	290	1,200	1,300	April 1992

TABLE 1
TPH CONTAMINATION
SOIL HOLDING PAD, BEALE AFB

			Soil Chemistry in $\mu g/kg$								
Site	# of Collected Collected	Soil Volume (a) (a)	TPH Range	TPH Diesel 8015 (Max)	TPH Gasoline 8015 (Max)	TPH 418.1 (Max)	Benzene (Max)	Toluene (Max)	Ethyl Benzene (Max)	Xylenes (total) (Max)	Date of Excavation
2458	4	10	ND–100,000	ND	NA	100,000	ND	ND	ND	ND	April 1992
2459	4	10	ND–14,000	ND	NA	14,000	ND	ND	ND	ND	April 1992
2471	5	2,000	ND–2,400,000	2,400,000	NA	37,000	ND	140	490	2,400	April 1992
2472	3	15	ND–34,000	4,900	NA	34,000	ND	ND	ND	ND	April 1992
2474	2	5	n.a.	ND	NA	NA	ND	ND	ND	ND	April 1992
2475	3	5	ND–14,000	ND	NA	14,000	ND	ND	ND	ND	April 1992
2476	3	5	ND–47,000	ND	NA	47,000	ND	ND	ND	ND	April 1992
2477	3	5	ND–24,000	ND	NA	24,000	8.7	ND	ND	ND	April 1992
2489	6	5	3,700–700,000	700,000	8,000	560,000	ND	ND	ND	39	April 1992
2491	4	5	5,000–36,000	5,200	NA	36,000	ND	ND	ND	ND	April 1992
2493	5	10	ND–580,000	580,000	14,000	530,000	ND	ND	17	66	April 1992
2496	7	1,500	ND–640,000	240,000	18,000	640,000	ND(c)	750	170	970	May 1992
2479	6	500	ND–510,000	510,000	NA	68,000	ND	ND	8.6	54	April 1992
2535	2	5	ND–8,000	8,000	NA	NA	ND	ND	ND	5.3	April 1992
2536	2	10	2,000–2,800	2,800	NA	NA	ND	ND	ND	ND	April 1992
2539.1	2	20	2,300–220,000	2,300	NA	22,000	ND	ND	ND	ND	April 1992
2539.2	1	5	ND–2,000	2,000	NA	NA	ND	ND	ND	ND	April 1992
2541	3	5	2,600–30,000	2,600	NA	30,000	ND	ND	ND	ND	April 1992
2548.1	3	50	ND–35,000	35,000	NA	NA	ND	ND	ND	ND	June 1992
2548.2	4	50	ND–26,000	ND	NA	26,000	ND	ND	ND	ND	June 1992
2560	3	30	3,800–170,000	9,700	NA	170,000	ND	ND	ND	ND	April 1992
2696	3	10	2,700–1,200,000	1,200,000	NA	72,000	ND	12	11	200	April 1992
22–A1	5	0	n.a.	ND	ND	NA	ND	120(d)	ND	ND	Oct. 1990
22–A2	5	3	n.a.	ND	ND	NA	ND	36(d)	ND	ND	Sept. 1990
22–A3	9	2	1,500–320,000	320,000	48,000	NA	30	240(d)	23	180	Sept. 1990
22–A4	5	0	59,000	59,000	ND	NA	ND	100(d)	ND	ND	Sept. 1990
22–A5	3	0	n.a.	ND	NA	NA	ND	ND	ND	ND	Oct. 1990
22–A7	2	0	16,000–17,000	17,000	NA	NA	ND	ND	ND	ND	Sept. 1990
22–A8	5	97	38,000–89,000	890,000	NA	NA	0.7	8.5(d)	1.4	ND	Oct. 1990
22–A9	4	14	n.a.	ND	NA	NA	ND	130(d)	0.5	ND	Oct. 1990
22–A10	7	131	45,000–8,200,000	8,200,000	ND	NA	ND	130	ND	ND	Sept. 1990
22–A11	4	351	3,800,000	3,800,000	NA	NA	ND	110(d)	ND	ND	Sept. 1990
22–A12	9	35	320,000–4,100,000	4,100,000	NA	NA	ND	160	780	2,300	Sept. 1990
22–A13	11	896	170,000–1,500,000	1,500,000	NA	NA	ND	120	19	ND	Oct. 1990
22–A14	4	0	n.a.	ND	NA	NA	ND	32(d)	ND	ND	Oct. 1990
22–A15	1	(e)	n.a.	ND	NA	NA	ND	7(d)	ND	ND	Oct. 1990
22–A16	7	139	23,000–810,000	810,000	NA	NA	ND	170(d)	ND	ND	Oct. 1990
22–A17	4	2	24,000–3,400,000	3,400,000	NA	NA	ND	68(d)	ND	8.4	Oct. 1990
22–A18	1	9	36,000–190,000	190,000	NA	NA	ND	140(d)	ND	ND	Oct. 1990
22–A20	9	600	1,100,000–6,900,000	6,900,000	NA	NA	140	1,500	180	16,000	Oct. 1990

TABLE 1
TPH CONTAMINATION
SOIL HOLDING PAD, BEALE AFB

Site	# of Collected Collected	Soil Volume (a) (a)	TPH Range	TPH Diesel 8015 (Max)	TPH Gasoline 8015 (Max)	TPH 418.1 (Max)	Benzene (Max)	Toluene (Max)	Ethyl Benzene (Max)	Xylenes (total) (Max)	Date of Excavation
			Soil Chemistry in $\mu g/kg$								
22-A21	3	80	880,000	880,000	NA	NA	ND	120(d)	ND	9.9	Oct. 1990
22-A22	3	2	n.a.	ND	NA	NA	ND	18(d)	ND	ND	Oct. 1990
22-A25	7	6	120,000-1,700,000	17,000,000	NA	NA	ND	46(d)	ND	ND	Oct. 1990
22-B2	1	2	370,000	370,000	NA	NA	NA	35(d)	NA	NA	Oct. 1990

Notes:

NA = Not Analyzed n.a. = Not Applicable
ND = Not Detected NR = Not Recorded
(a) During 1990, soil placed at the soil holding area was screened with a PID.
During 1992, no such protocols are known and therefore soil with ND values may be included.
(b) Motor oil with concentration of 180 mg/kg found in sample.
(c) Detection Limit = 100 due to dilution factor.
(d) Probable false positive for toluene due to use of tape for sealing sample.
(e) Single excavation for 22-A15 and 22-A16.

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TABLE 2
ENVIRONMENTAL RESTORATION PROJECTS
TPH SOIL TREATMENT
Beale Air Force Base, California

Chemical	Hazard Potential	Hazardous Concentrations PEL (ppm)	TLV (ppm)	IDLH (ppm)	Odor Threshold (ppm)	Ionization Potential (eV)	Route of Exposure	Recognition Qualities	Symptoms of Exposure	Last Update
ORGANICS										
Benzene	OSHA-regulated carcinogen Highly flammable Moderate explosion hazard	1 (TWA)	10 (TWA)	2,000	4.68	9.25	Inhalation Absorption Ingestion Eye contact	Colorless liquid with aromatic solvent odor	Eye, nose, respiratory irritation; giddiness; nausea; headache; staggered gait; fatigue; dermatitis; abdominal pain	08/16/90
Diesel Fuel	Moderate fire/ explosion hazard						Inhalation Absorption Ingestion	Pale yellow oily liquid	Headache; stupor; nausea; vomiting; pneumonitis	08/16/90
Ethylbenzene	Dangerous when exposed to heat or flame	100 (TWA)	100 (TWA)	2,000	0.25-200	8.76	Inhalation Ingestion Absorption	Colorless liquid with an aromatic odor	Eye and mucous membrane irritation; headache; dermatitis dermatitis; narcosis, coma	08/16/90
Gasoline	Highly flammable Explosive vapors	300 (TWA)	300 (TWA)		0.005-10	10.0-10.2	Inhalation Absorption	Clear aromatic volatile liquid	Dermatitis; pulmonary edema; hypermia of eye conjunctiva	08/16/90
Jet Fuel (JP-4)	Flammable		200 (TWA)	NA	1		Inhalation Asborption Ingestion	Brown Liquid	Eye and throat irritation; headace, stuper, vomiting pneumanitis	10/31/90
Toluene	Flammable Slight fire hazard Moderate explosion hazard	100 (TWA)	50 (TWA)	2,000	0.17-40	8.82	Inhalation Absorption Ingestion Eye contact	Colorless liquid with benzene-like odor	Dizziness; headache; fatigue and weakness; confusion; tearing; nervousness; dermatitis	4/5/92
Xylene (all isomers)	Flammable	100 (TWA)	100 (TWA)	10,000	0.05	8.56	Inhalation Absorption	Colorless liquid with aromatic odor (p-xylene is solid)	Dizziness; drowsiness; excitement; incoordination; staggering gait; eye, nose, throat irritation; nausea; vomiting; abdominal pain; dermatitis	08/16/90

NOTES:

PEL	Permissable Exposure Limit, Title 29, CFR, Department of Labor, Occupational Safety and Health Administration
TLV	Threshold Limit Value, 8 hour time weighted average, American Conference of Governmental Industrial Hygienists
IDLH	Immediately Dangerous to Life and Health, National Institute of Occupational Safety and Health
TWA	Time Weighted Average

35-34t.wk3 4/5/93

When the potential for heat stress is present, such as when temperature is greater than 80 degrees and weather is sunny, or if personnel are required to go to Level C, field crews need to be especially vigilant to monitor for the symptoms. The Project Health & Safety Officer will monitor the field crew for heat stress symptoms and take appropriate action as described in Appendix E.

The ES field crew will bring an adequate supply of potable water to the site to help insure replacement of fluid lost through sweating and evaporation. In addition to water, other applicable liquids may be provided for salt and mineral replacement. It is important that water intake during a work period is sufficient to prevent dehydration.

Workers exposed to heat should be encouraged to salt their food abundantly. Large amounts of salt may be lost in the sweat, particularly by the individual not acclimatized to heat; this loss must be replaced daily to prevent illness (heat cramps) due to salt deficiency. A table describing heat stress symptoms, prevention, and treatment is included in Appendix E. ES employees on site will be especially careful to avoid succumbing to heat stress by maintaining a flexible work schedule, resting whenever necessary, wearing light colored clothes and a hat, and avoiding alcohol. These considerations are especially important given that employees on the site may not be acclimatized to heat.

Contingency and Spill Plan

All personnel going on-site must be thoroughly briefed on anticipated hazards, safety practices, personal protective equipment use, emergency procedures, and chemical/personal injury incidence reporting. A discussion of these contingencies and general health and safety procedures is included in Appendix F. Should an emergency situation arise as a result of a significant release of a petroleum hydrocarbon material, the Beale AFB Spill Prevention and Response Program (Appendix G) will be initiated. Attachment 4 of the Spill Prevention and Response Program specifies procedures to be used for individuals discovering a spill.

6.0 LEVELS OF PERSONAL PROTECTION REQUIRED FOR SITE ACTIVITIES

Personal protective equipment that will be required on-site is divided into respiratory and dermal protection. The assigned protective levels are either C or D for respiratory and dermal protection depending on field conditions. The Project Health & Safety Officer will be responsible for setting protection levels for on-site work.

Dermal Protection

Personal Protective Equipment

Dermal protection for Level D includes: chemical-resistant (i.e., Nitrile) gloves, standard work clothes or Tyvek suits, safety glasses, hard hat and steel-toed/shanked boots. Steel-toed rubber boots and Saranex coveralls should be worn if bodily contact with wet contaminated soils or groundwater appears likely. Hardhats must be worn when working around heavy equipment. In addition, traffic vests will be worn by personnel when working near streets.

Dermal protection for Level C includes the following items to supplement Level D protection: Impermeable (e.g., Saranex) suits, disposable inner and taped impermeable outer gloves.

Dermal Protection Criteria

Dermal protection levels will be chosen based on field activities performed. For field activities that do not involve direct contact with contaminated soil or groundwater Level D protection will be used. If activities involve risk of direct contact with contaminated material, then Level C protection will be used. Level C dermal protection must be used if Level B respiratory protection is used.

Respiratory Protection

Personal Protective Equipment

Level D Operations Requirements. No respiratory protection.

Level C Operations Requirements. Full facepiece air purifying respirator (APR) equipped with organic vapor cartridges (NIOSH approved).

Level B Operations Requirements. This level of respiratory protection is required for atmospheres with: 1) concentrations of known substances greater than protective factors associated with full facepiece air purifying respirators, 2) concentrations of known substances exceeding 40 percent of the substance IDLH level, or 3) less than 19.5 percent oxygen. Respiratory protection requirements are:

- Pressure-demand full facepiece, self-contained breathing apparatus (SCBA) or pressure-demand supplied air respirator with escape SCBA (NIOSH approved).
- Note: ***Level B operations require approval from ES Corporate Health and Safety.***

Respiratory Protection Criteria

Potential contaminants in soil on site are listed in Table 1, along with relevant personal exposure limits and warning properties. Exposures are most likely to occur during the movement and placement of soils on the treatment pad, during O&M activities, and during soil sampling. Decisions on appropriate respiratory protection will be based on air monitoring of worker breathing zones using a photoionization detector (PID) and chemical-specific colorimetric tubes as described below. In most cases, worst-case air monitoring of the source (e.g., contaminated soil) should be conducted to determine the presence of any contaminants. If air contaminants are detected, samples must be taken in the breathing zone to determine whether exposure levels exceed PELs/TLVs and therefore require use of a respirator. All air sampling results will be recorded on Air Monitoring Forms (Appendix A).

Selection of respiratory protection will be based on the following criteria. Table 3 summarizes these criteria which should be utilized based on contaminants expected at the various subsites.

TABLE 3

RESPIRATORY PROTECTION CRITERIA
BEALE AFB, CA.

Notes: a) In addition to using the criteria below, a safe, upwind location should be identified or the area should be ventilated in an attempt to reduce PID readings in the breathing zone.

b) Criteria must be followed in order, i.e. Criteria 1 must be satisfied before using Criteria 2.

Criteria 1: PID > 1 ppm for one minute period

Sample with benzene detector tube.

- If benzene < 1 ppm and PID < 10 ppm, then no protection is needed.
- If benzene > 1 ppm and no safe, upwind location can be identified, cease work*.

Criteria 2: PID > 10 ppm for one minute period

Because this table represents a general guidance for contaminants that have previously been detected at the site, it is recommended that APR with organic vapor cartridges (Level C) be used if PID > 10 ppm and no safe upwind location can be identified.

Criteria 3: PID > 50 ppm for one minute period

APR should already be in use based on Criteria 2.

- If ethylbenzene > 100 ppm and no safe, upwind location can be identified, cease work*.
- If toluene > 50 ppm OR xylenes > 100 ppm OR gasoline > 300 ppm, APR with organic vapor cartridges is required to continue work.

Criteria 4: PID > 800 ppm (40% of IDLH for benzene, ethylbenzene, and toluene)

Cease work*.

* Corporate approval is required before work may continue using Level B (SCBA).

7.0 HEALTH AND SAFETY EQUIPMENT

The on-site field team will have the following health and safety equipment readily available, as necessary, whenever conducting site activities:

- Copy of the Health and Safety Plan
- First-aid kit
- Eyewash bottle
- Duct tape
- Paper towels

- Fire blanket
- Fire extinguisher
- Plastic garbage bags
- Insulated water cooler filled with appropriate liquids
- Photovac TIP or OVM Model 580A or Photovac Microtip
- Sensidyne gas pump with benzene, toluene, ethylbenzene, xylene, and gasoline colorimetric tubes
- LEL meter
- Respirator with organic vapor cartridges
- Tyvek/Saranex suit
- Chemical gloves
- Earplugs

8.0 AIR MONITORING

Air monitoring will be performed to evaluate potential explosive conditions and personal exposure to hazardous substances at the site during field activities. Air monitoring results will be documented on the form provided in Appendix A; these results will be placed in the Health and Safety office plan file. Decisions concerning respirator use will be based upon the air monitoring results. The following instruments and monitoring will be conducted when appropriate:

Type of Equipment	Minimum Calibration Frequency	Parameter(s) to be Measured	Minimum Sampling Frequency	Sampling Locations
Photoionization detector (PID)	Daily	Total organic vapor	Hourly	Soil holding piles, treatment piles, and at *in situ* extraction or vent wells
Sensidyne gas pump with appropriate colorimetric tubes	Does not apply	Specific organics (e.g. gasoline, benzene, toluene, xylene)	As needed	Soil holding piles, treatment piles, and at *in situ* extraction or vent wells
LEL meter	Each use	Oxygen deficiency and flammable or explosive atmosphere	As needed	Soil holding piles

The photoionization detector (PID) will be calibrated with 100 ppm isobutylene (span gas) and the surrounding air once per day. The calibration will be checked at the end of each day by taking a PID reading of the span gas. The LEL meter will be calibrated to either 2.5% natural gas in air or a 40% hexane gas in air mixture.

9.0 PERSONAL AIR SAMPLING

Personal air sampling will be performed using full-shift personal sampling pump samples on ES employees involved in operations utilizing Level C or Level B respiratory protection. At least one full-shift sample will be acquired during the course of each Level C or Level B operation, and will be collected at the breathing zone of the ES employee subject to the highest potential concentrations of contaminants.

Collected personal air samples will be analyzed for all contaminants that potentially occur at the specific contaminated area. Each personal air sample will be collected utilizing a personal sampling pump with the appropriate sorbant/cartridge for the analytical methods. Calibration of the sampling pump will be performed prior to and immediately after completion of each sample. Samples will be submitted under chain-of-custody protocols to an AIHA-certified Industrial Hygiene Laboratory. Analyses will be performed as described in the NIOSH Manual of Analytical Methods. Sampling procedures and required parameters will be documented by completing personal air sample data forms (Appendix A). Particular care should be taken to record start/stop times, sample numbers, flow rates, and pump numbers. A field blank for each analytical method will be submitted and analyzed. A field blank will be collected for each day of sampling, and will consist of a sorbant/cartridge opened momentarily then sealed on-site. Blank samples will be identified only in the field logbook, and will be assigned sample numbers and recorded on personal air sample data forms that are submitted to the laboratory so as to conceal their nature.

10.0 SITE CONTROL MEASURES

Site control measures will be followed in order to minimize potential contamination of workers, protect the public from potential site hazards, and control access to the sites. Site control involves the physical arrangement and control of the operation zones and the methods for removing contaminants from workers and equipment.

Control boundaries at the site will be established with "caution tape", pylons, or other measures as necessary. Should chemical exposure through the respiratory pathway exceed the levels established in this plan, work will cease and the site will be cleared of personnel and bystanders until the potential exposure hazard is under control. The Site Health and Safety Officer will implement boundary control and site containment measures if necessary. The Site Health and Safety Officer will also designate places of refuge and safe distances to be used in the event of an emergency. These areas will be located upwind of the project site.

Specific site-control procedures at this site will include establishment of site work zones whenever employees are wearing respiratory protection. Unauthorized personnel will be restricted from entering the immediate work area.

11.0 DECONTAMINATION PROCEDURES

Minimum decontamination procedures are anticipated for most work after review of existing information about the site. Whenever possible, disposable outer wear (e.g. gloves and suit) should be utilized for soil sampling/excavation procedures. Soiled re-usable outerwear (e.g. boots) should be washed with an Alconox solution and rinsed with water. Respirators should be washed with respirator cleaning solution.

APPENDIX A
FORMS

PROJECT HEALTH AND SAFETY
PLAN ACCEPTANCE FORM

PROJECT HEALTH AND SAFETY PLAN
BRIEFING ACKNOWLEDGMENT

I have attended a tailgate Health & Safety meeting
and agree to abide by the contents of **my employer's**
Health and Safety Plan
for
Surface Bioventing Treatability Study
at the
Beale AFB
Yuba County, California

Name (Print)	Signature	Company	Date

Return to: Dennis J. Brown
Facility Health and Safety Representative
Engineering-Science, Inc., Alameda

35-34.R0 4/5/93

RESPIRATOR USAGE LOG

RESPIRATOR USAGE LOG

BEALE AIR FORCE BASE
YUBA COUNTY, CALIFORNIA

Employee Name	Emp. #	Date of Use	Cleaned and Inspected Before Use (Initials)	Cartridges Changed Before Use (Yes, No, N/A)	Total Hours on Cartridge

Project Health and Safety Officer or
ES Project Manager

Date

Return to Office Health and Safety Representative at the completion of field activities.

AIR MONITORING SHEET

AIR MONITORING DATA

SAMPLING DATE/TIME	CONCENTRATION (ppm)		PERSONNEL MONITORED	INSTRUMENT MAKE/MODEL	LAST CALIBRATED	SAMPLE LOCATION	RESPIRATOR USED? (Y/N)
	BREATHING	SOURCE					

WRITE THE NAME/SIGNATURE OF PERSON(S) CONDUCTING AIR MONITORING AND THE SAMPLING DATE(S)

SUBMIT COPIES OF THIS FORM TO THE HEALTH & SAFETY OFFICE AND THE PROJECT FILE

05/21/91
601-44.wk1/all

ACCIDENT REPORT FORM

BEALE AIR FORCE BASE
YUBA COUNTY, CALIFORNIA

EMPLOYER

1. Name:______________________________

2. Mail Address______________________________
   (No. and Street) (City or Town) (State and Zip)

3. Location, if different from mail address:

   ____

INJURED OR ILL EMPLOYEE

4. Name: ____________________ Social Security #:________________
   (first) (middle) (last)

5. Home Address:______________________________
   (No. and Street) (City or Town) (State and Zip)

6. Age: ________ 7. Sex: Male ( ) Female ( )

8. Occupation:______________________________
   (Specific job title, <u>not</u> the specific activity employee was performing at time of injury)

9. Department: ______________________________
   (Enter name of department in which injured person is employed, even though they may have been temporarily working in another department at the time of injury)

THE ACCIDENT OR EXPOSURE TO OCCUPATIONAL ILLNESS

10. Place of accident or exposure:______________________________
    (No. and street) (City) (State and Zip)

11. Was place of accident or exposure on employer's premises? Yes ( ) No ( )

12. What was the employee doing when injured? (Be specific -- was employee using tools or equipment or handling material?) ______________________________

    ____

    ____

13. How did the accident occur? (Describe fully the events that resulted in the injury or occupational illness. Tell what happened and how. Name objects and substances involved. Give details on all factors that led to accident. Use separate sheet for additional space.) ______________________________

____

____

14. Time of accident: ____________________

15. ES witness(es) to accident

______ (Name)	(Affiliation)	(Phone No.)
(Name)	(Affiliation)	(Phone No.)
(Name)	(Affiliation)	(Phone No.)

OCCUPATIONAL INJURY OR OCCUPATIONAL ILLNESS

16. Describe injury or illness in detail; indicate part of body affected: ____________________

____

____

17. Name the object or substance that directly injured the employee. (For example, object that struck employee; the vapor or poison inhaled or swallowed; the chemical or radiation that irritated the skin; or in cases of strains, hernias, etc., the object the employee was lifting, pulling, etc.) ____________

____

____

18. Date of injury or initial diagnosis of occupational illness: ____________________

19. Did the accident result in employee fatality? Yes ( ) No ( )

20. Name and address of physician: ______________________________

____

21. If hospitalized, name and address of hospital: ______________________________

____

Date of report: ______________ Prepared by: ______________________

Official position: ______________________________

APPENDIX B

PROJECT TEAM RESPONSIBILITIES

APPENDIX B

PROJECT TEAM RESPONSIBILITIES

PROJECT MANAGER

The project manager shall direct the on-site investigation and operation efforts. The project manager has the primary responsibility for:

- Assuring that appropriate personnel protective equipment is available and is properly utilized by all on-site ES personnel. The project manager shall also advise subcontractors as to the necessity and appropriateness of personal protective equipment and may, if the situation requires, remove subcontractors from the job for practicing unsafe procedures;
- Assuring that personnel are aware of the provisions of this plan and are instructed in the work practices necessary to ensure safety and the procedures for dealing with emergencies;
- Consulting with the health and safety coordinator;
- Assuring that personnel are aware of potential hazards associated with site operations;
- Monitoring the safety performance of all personnel to ensure that the required work practices are employed;
- Correcting any work practices or conditions that may result in injury or exposure to hazardous substances;
- Preparing accident/incident reports (see Appendix A); and
- Assuring the completion of the Plan Acceptance Form (see Appendix A) by all personnel prior to their going on site, and ensuring that they understand the provisions of the form.

PROJECT HEALTH AND SAFETY OFFICER

Unless the project is designated by the ES Project Manager to be hazardous enough to require a professional safety person, the Project Health and Safety Officer will be a member of the assigned project team who is responsible for site safety. The responsibilities of the health and safety officer will be:

- Establishing and directing the safety program;

- Conducting a tailgate Health & Safety meeting with all persons new to the site;
- Advising and consulting with the site manager on all matters related to the health and safety of those involved in site operations;
- Directly supervising, in the field, the health and safety aspects of response activities when necessary; and
- Carrying a list of emergency contacts on person.

PROJECT PERSONNEL

Project personnel involved in field investigations and operations are responsible for:

- Taking all possible precautions to prevent injury to themselves and to other employees;
- Implementing the Site Safety Plan and reporting to the project manager, site manager, or safety officer any deviations from the anticipated conditions described in the plan; and
- Performing only those tasks which they believe they can do safely, and immediately reporting any accidents or unsafe conditions to the project manager, on-site supervisor, or safety officer.

APPENDIX C

TRAINING AND MEDICAL MONITORING

APPENDIX C

TRAINING AND MEDICAL MONITORING

The ES employees that will be involved in site activities are enrolled in a medical surveillance program. This program requires the employees to receive a baseline physical and yearly check-up exams. The tests performed during the annual exam follow this section. Additional medical monitoring will be included whenever necessary. In the event that an employee is exposed to adverse levels of contaminants during site work, the employee will be examined in order to evaluate and treat potential health problems resulting from the exposure.

ES employees involved in field work have received 40 hours of health and safety training meeting the requirements of 29 CFR 1910.120, Paragraph E. ES employees who may need to wear respirators during site activities will receive instructions, demonstration and practice on how the respirator should be worn, how to adjust it, and how to determine if the respirator fits properly (29 CFR 1910.134). Health and safety personnel working at the site will be familiar with the operation, calibration, and limitations of all field monitoring equipment.

ANNUAL MEDICAL EXAMINATION

Each ES employee's annual medical examination will involve compiling an interval medical history and undergoing a thorough medical examination as outlined below.

INTERVAL MEDICAL HISTORY

An interval medical history will be provided focusing on changes in health status, illnesses, and possible work-related symptoms. The worker will provide the examining physician with information about the worker's interval exposure history, including exposure monitoring results (if performed).

PHYSICAL EXAMINATION

The medical examination will include the following:

- Height, weight, temperature, pulse, respiration, and blood pressure.
- Head, nose, throat.
- Vision tests that measure refraction, depth perception, and color vision.
- Chest (heart and lungs).
- Peripheral vascular system.
- Abdomen and rectum (including hernia exam).
- Spine and other components of the musculoskeletal system.
- Genitourinary system.
- Skin.
- Nervous system.
- Blood test.
- Urine test.

ADDITIONAL TESTS

Additional medical testing may be performed, depending on available exposure information, medical history, and examination results. Testing should be specific for the possible medical effects of the worker's exposure. Multiple testing for a large range of potential exposures is not always useful: it may involve invasive procedures (e.g., tissue biopsy), be expensive, and produce false-positive results.

Pulmonary Function

A pulmonary function test should be administered if the individual uses a respirator, has been or may be exposed to irritating or toxic substances, or if the individual has breathing difficulties, especially when wearing a respirator.

Audiometric Tests

Annual retests are required for personnel subject to high noise exposures (an 8-hour, time-weighted average of 85 dBA or more), those required to wear hearing protection, or as otherwise indicated.

Electrocardiogram

An electrocardiogram (EKG) will be performed annually for those over 40 years of age, and every three years for all others. The EKG will be the standard 12-lead resting type.

Chest X-Rays

Chest x-rays will be performed when clinically indicated or every three years. The x-ray should be at least 14 by 17-inch P-A (posterior/anterior).

Blood and Urine Test

The blood and urine tests frequently performed by occupational physicians include:

Blood Test

- Complete blood count with differential and platelet evaluation
- White cell count
- Red cell count
- Hemoglobin
- Hematocrit
- Reticulocyte count
- Total protein
- Albumin
- Globulin
- Total bilirubin
- Alkaline phosphatase
- Gamma glutamyl transpeptidase (GGTP)
- Lactic dehydrogenase (LDH)
- Serum glutumigoxaloacetic transaminase (SGOT)
- Serum glutamic-pyruvic transaminase (SGPT)
- Blood urea nitrogen (BUN)

- Creatinine
- Uric Acid

Urinalysis

- Color
- Specific gravity
- pH
- Qualitative glucose
- Protein
- Bile
- Acetone
- Microscopic examination of centrifuged sediments

APPENDIX D

CHEMICAL HAZARDS

PETROLEUM HYDROCARBONS

Petroleum hydrocarbons are family of petroleum based compounds consisting of carbon and hydrogen. A wide variety of branched, straight-chain and ringed structures is possible given the nature of the way carbon bonds to itself and hydrogen. Petroleum hydrocarbons exist as solids, liquids and gases. Some common liquid petroleum hydrocarbons include: gasoline, diesel fuel, fuel oil, jet fuel, and kerosene. These liquids are complex mixtures containing numerous species of hydrocarbon. The toxicity and environmental behavior of these fuel mixtures, and any additives, depends on the mixture constituents. Gasoline, for instance, is a mixture containing approximately 150 different hydrocarbon species, several elements (in small concentrations), and fuel additives such as: ethylene dibromide, ethylene dichloride, tetramethyl lead, and tetraethyl lead. The constituent of most concern in these fuels is benzene, a known human carcinogen, which may consist of up to 5% of the total volume in gasoline. The main routes of exposure to petroleum hydrocarbons are inhalation and skin absorption. Another major hazard to consider in dealing with petroleum hydrocarbon fuels is fire and explosion. If gasoline vapors reach 1.4 to 7.6% in air, a violent explosion may occur in the presence of an ignition source. Acute exposure to petroleum hydrocarbons primarily cause Central Nervous System (CNS) effects such as: headache, dizziness, weakness and loss of coordination, loss of consciousness and death. Chronic exposure to petroleum hydrocarbons may cause: skin drying and irritation upon repeated skin exposure, cancer, peripheral neuropathy, and decreased immunologic response. These health effects are highly dependent upon exposure concentration and duration. Personal protection against exposure to petroleum hydrocarbons would include primarily respiratory and dermal protection. The Occupational Safety and Health Administration (OSHA) has set limits for exposure to many of the constituents of petroleum hydrocarbon fuels. Below is a table which describes the OSHA exposure limits (PEL's) and ACGIH (TLV's) for some petroleum hydrocarbon constituents.

COMPOUND	ABBREVIATION	PEL/TLV	CARC./REP. HAZARD
Gasoline	--	300/300	yes/no
Benzene	C_6H_6	1.0/10.0	yes/no
Toluene	$C_6H_5CH_3$	100/50	no/no
Xylene	$C_6H_5(CH_3)_2$	100/100	no/no
Tetraethyl lead	TEL	0.075/0.1	no/no
Tetramethyl lead	TML	0.075/0.15	no/no
Ethylene dibromide	EDB	20/0.045	yes/no

PEL/TLV expressed as parts per million (ppm) except for TEL and TML which are expressed as mg/m^3

APPENDIX E
PHYSICAL HAZARDS

TABLE E

HEAT STRESS SYMPTOMS, PREVENTION & TREATMENT

	Heatstroke and Heat Hyperpyrexia
Symptoms	*Heatstroke:* (1) hot dry skin; red, mottled, or cyanotic; (2) high and rising core temperature, 40.5°C or over; (3) brain disorders; mental confusion, loss of consciousness, convulsions, or coma, as core temperature continues to rise. Fatal if treatment delayed. *Heat Hyperpyrexia:* milder form; core temperature lower; less severe brain disorders; some sweating.
Treatment	*Heatstroke:* immediate and rapid cooling by immersion in chilled water with massage, or by wrapping in wet sheet with vigorous fanning with cool dry air. Avoid overcooling. Treat shock if present. *Heat hyperpyrexia:* less drastic cooling required if sweating still present and core temperature <40.5°C.
Prevention	Medical screening of workers. Selection based on health and physical fitness. Acclimatization for 8 to 14 days by graded work and heat exposure. Monitoring workers during sustained work in severe heat.

	Heat Syncope
Symptoms	Fainting while standing erect and immobile in heat.
Treatment	Remove to cooler area. Recovery prompt and complete.
Prevention	Acclimatization. Intermittent activity to assist venous return to heart.

	Heat Exhaustion
Symptoms	(1) Fatigue, nausea, headache, giddiness; (2) skin clammy and moist, complexion pale, muddy, or with hectic flush; (3) may faint on standing, with rapid thready pulse and low blood pressure; (4) oral temperature normal or low but rectal temperature usually elevated (37.5 to 38.5°C). Water-restriction type: urine volume small, highly concentrated. Salt-restriction type: urine less concentrated, chlorides less than 3 g/liter.
Treatment	Remove to cooler environment. Administer salted fluids by mouth or give intravenous infusions of normal saline (0.9 percent) if patient is unconscious or vomiting. Keep at rest until urine volume and salt content indicate that salt and water balances have been restored.
Prevention	Acclimatize workers using a breaking-in schedule for 1 or 2 weeks. Supplement dietary salt only during acclimatization. Ample drinking water to be available at all times and to be taken frequently during work day.

TABLE E (Continued)

	Heat Cramps
Symptoms	Painful spasms of muscles used during work (arms, legs, or abdominal). Onset during or after work hours.
Treatment	Salted liquids by mouth, or more prompt relief by intravenous infusion.
Prevention	Adequate salt intake with meals. In unacclimatized men, provide salted (0.1 percent) drinking water.

	Heat Rash
Symptoms	Profuse tiny raised red vesicles (blisterlike) on affected areas. Pricking sensations during heat exposure.
Treatment	Mild drying lotions. Skin cleanliness to prevent infection.
Prevention	Cooled sleeping quarters to allow skin to dry between heat exposures.

	Heat Fatigue-Transient
Symptoms	Impaired performance of skilled sensorimotor, mental, or vigilance tasks, in heat.
Treatment	Not indicated unless accompanied by other heat illness
Prevention	Acclimatized and training for work in the heat.

APPENDIX F

GENERAL HEALTH AND SAFETY PROCEDURES
AND
EMERGENCY PROCEDURES

APPENDIX F

GENERAL HEALTH AND SAFETY PROCEDURES AND EMERGENCY PROCEDURES

GENERAL HEALTH AND SAFETY PROCEDURES

All personnel going on site must be thoroughly briefed on anticipated hazards, safety practices, emergency procedures, and communications, and should be trained on equipment to be worn.

The safety practices listed below must be followed:

- All respirator users must be medically cleared.
- Any required respiratory protective devices and clothing must be worn by all personnel going into areas designated for wearing protective equipment.
- Personnel must be fit-tested prior to use of respirators.
- No facial hair which interferes with a satisfactory fit of the mask-to-face seal is allowed on personnel who are required to wear respirators.
- No contact lenses shall be worn on site.
- Contact with contaminated or suspected surfaces should be avoided. Whenever possible, do not walk through puddles, leachate, or discolored surfaces; or lean, sit, or place equipment on drums, containers, or soil suspected of being contaminated.
- Eating, drinking, chewing gum or tobacco, smoking, or any practice that increases the probability of hand-to-mouth transfer and ingestion of material is prohibited in any area designated as contaminated.
- Personnel should practice unfamiliar operations prior to doing the actual procedure in the field.
- Field crew members shall be familiar with the physical characteristics of the site, including:
  - wind direction in relation to contamination zones (wind indicators visible to all on-site personnel should be provided to indicate possible routes of upwind escape);
  - accessibility to associates, equipment, and vehicles;
  - communications;

- exclusion zones;
- site access; and
- nearest water sources.

- Personnel on site must use the buddy system (pairs), when wearing respiratory protective equipment. As a minimum, a third person, suitably equipped as a safety backup, is required during initial entries of sites requiring respiratory protection. Buddies should pre-arrange hand signals or other means of emergency signaling for communication in case of lack of radios or radio breakdown (see the General Emergency Procedures).
- Visual contact must be maintained between pairs on site and between site safety personnel. Entry team members should remain close together to assist each other in case of emergencies.
- All field crew members should make use of their senses to alert themselves to potentially dangerous situations which they should avoid, e.g., presence of strong and irritating or nauseating odors. However, they should never rely upon the sensory information as the basis for safety decision-making.
- Personnel and equipment in the contaminated area should be kept to a minimum, consistent with effective site operations.
- Procedures for leaving a contaminated area must be planned and implemented prior to going on site in accordance with the site specific health and safety plan.
- Hands and face must be thoroughly washed upon leaving the work area.
- Whenever decontamination procedures for outer garments are in effect, the entire body should be thoroughly washed as soon as possible after the protective garment is removed.
- Medicine and alcohol can exacerbate the effects from exposure to toxic chemicals. Prescription drugs should not be taken by personnel on response operations where the potential for absorption, inhalation, or ingestion of toxic substances exists unless specifically approved by a qualified physician. Alcoholic beverage intake should be avoided during response operations.

An on-site orientation session will be required for all on-site personnel and will include the following:

- Health effects and hazards of the chemicals identified or suspected to be on site.
- Personal protection including:
  - Use, care, and fitting of personal protection equipment; and
  - Necessity for personal protection, its effectiveness, and limitations of equipment.
- Decontamination procedures.

- Any prohibitions in areas and zones, including:
  - Site layout;
  - Procedures for entry and exit of areas and zones; and
  - Standard safe work practices.
- Emergency procedures, including:
  - Emergency contacts;
  - Instructions for implementing the emergency plan; and
  - Location of emergency equipment.

Additionally, routine health and safety meetings shall be held at the discretion of the project manager or project health and safety officer. As part of the general safety training program, ES employees participate in Red Cross First Aid and CPR courses to more effectively handle physical and medical emergencies that may arise in the field. In addition, all subcontractors hired by ES are required to have the federally mandated 40-hour Hazardous Waste Operations Instruction as well as a medical monitoring program.

EMERGENCY PROCEDURES

All hazardous waste site activities present a degree of risk to on-site personnel. During routine operations, risk is minimized by establishing good work practices, staying alert, and using proper personnel protective equipment. Unpredictable events such as physical injury, chemical exposure, or fire may occur and must be anticipated.

Emergency conditions are considered to exist if:

- Any member of the field crew is involved in an accident or experiences any adverse effects or symptoms of exposure while on site; or
- A condition is discovered that suggests the existence of a situation more hazardous than anticipated.

General Emergency Procedures

The following emergency procedures should be followed:

- In the event of emergency, the contacts identified in the Emergency Contacts listing shall be notified as needed. This list should be posted conspicuously at the site.
- In emergencies, the following hand signals by field workers are suggested:
  - Hand gripping throat: out of air, can't breath.
  - Grip partner's wrist or place both hands around waist: leave area immediately, no debate!
  - Hands on top of head: need assistance.

- Thumbs up: Okay, I'm all right, I understand.
- Thumbs down: No, negative.

- In the event that any member of the field crew experiences any adverse effects or symptoms of exposure while on the scene, the entire field crew should immediately halt work and act according to the instructions provided by the project manager.
- The discovery of any condition that would suggest the existence of a situation more hazardous than anticipated should result in the evacuation of the field team and re-evaluation of the hazard and the level of protection required.
- In the event that an accident occurs, the project manager is to complete Accident Report Forms. Follow-up action should be taken to correct the situation that caused the accident.

Chemical Exposure

If any field crew demonstrates symptoms of chemical exposure the following procedures apply. At sites where two or more field crew members are involved, another team member (buddy) should remove the individual from the immediate area of contamination. At all sites, no matter how many personnel are involved, these procedures must be followed:

- Precautions should be taken to avoid exposure of other individuals to the chemical.
- If the chemical is on the individual's clothing, the clothing should be removed if it is safe to do so.
- If the chemical has contacted the skin, the skin should be washed with copious amounts of water, preferably under a shower.
- In case of eye contact, an emergency eye wash should be used. Eyes should be washed for at least 15 minutes.
- If necessary, the victim should be transported to the nearest hospital or medical center. An ambulance should be called to transport the victim, if necessary.
- All chemical exposure incidents must be reported in writing.

Personal Injury

In case of personal injury at the site, the following procedures are to be followed:

- Field team members trained in first aid should administer treatment to an injured worker.
- The victim should then be transported to the nearest hospital or medical center. If necessary, an ambulance should be called to transport the victim.
- The project manager is responsible for making certain that accident report forms are completed. These forms are to be submitted to the office health and safety representative. Follow-up action should be taken to correct the situation that caused the accident.

APPENDIX G

BEALE AFB SPILL PREVENTION AND RESPONSE PROGRAM

DEPARTMENT OF THE AIR FORCE
Headquarters 9th Combat Support Group (SAC)
Beale Air Force Base CA 95903-5000

BEALE AFB REGULATION 19-2

11 February 1988

Environmental Planning

SPILL PREVENTION AND RESPONSE

This regulation sets forth procedures for oil and hazardous substances spill prevention and responses. It includes the requirements of various federal laws and regulations, and AFR 19-1. It applies to Beale AFB organizations, tenant units and contractors.

1. REFERENCES:

a. AFR 19-1, Pollution Abatement and Environmental Quality.

b. AFR 19-8, Environmental Protection Committees and Environmental Reporting.

c. AFR 127-12, Air Force Occupational Safety, Fire Prevention and Health (AFOSH) Program.

d. BAFBR 19-1, Hazardous Waste (HW) and Recoverable Petroleum Management.

e. BAFB Disaster Preparedness Operations Plan 355-1.

2. ENVIRONMENTAL SETTING. BAFB is drained by four creeks that transverse the base. These creeks are Dry Creek (which prior to leaving the base divides into Dry Creek and Best Slough), Hutchinson Creek, Reeds Creek, and an unnamed creek located immediately east of Reeds Creek which flows southward toward Hutchinson Creek. Runoff from the base housing area empties into Dry Creek; the cantonment area drains into Hutchinson Creek, and runoff from the flightline and fire training area drains into the unnamed creek. Reeds Creek has had its flows augmented at the northern base boundary from ground water pumping discharges associated with dewatering of old hydraulic mine tailings being reworked to extract gold by Yuba Gold Fields, Inc. The water from gravel dewatering has been discharged to a canal that contributes flows toward Reeds Creek at the northern base boundary. Hutchinson and Reeds Creeks converge prior to draining into Plumas Lake southwest of the base. Dry Creek flows southwest for eventual discharge into the Bear River. A privately owned and operated irrigation water supply canal flows southwesterly along the base's northwest and western boundary. These water ways are navigable waters for purposes of spill response and spill reporting (see Atch 1).

3. CONCEPT OF SPILL PREVENTION AND RESPONSE (SPR). Accidental spills of hazardous substances may occur at any time. This regulation gives guidance for a basewide spill response program. All organizations will:

a. Make sure supervisors and workers know what constitutes oil and hazardous substances, their characteristics, and the hazards involved.

Supersedes BAFBR 19-2, 15 June 1985. (See signature page for summary of changes.)
No. of Printed Pages: 13
OPR: 9 CSG/DEEV (Kirk Schmalz)
Approved by: Colonel James F. Wilson
Editor: SSgt Jennifer M. Malone
Distribution: F;X

b. Identify each location as a potential spill site where oil and hazardous substances are handled, treated, or stored. Make a site specific spill plan for each potential spill site. (See paragraph 4f for definition of potential spill site.)

c. Identify and correct physical and procedural deficiencies at each potential spill site.

d. Make sure persons involved with oil and hazardous substances complete initial and refresher chemical safety and contingency training (see paragraph 22).

e. Refer to BAFB Disaster Preparedness Operation Plan 355-1 for available resources for major emergencies.

4. DEFINITIONS:

a. Environment: Navigable waters, other surface water, ground water, drinking water supply, land surface, subsurface strata, or ambient air.

b. Hazardous Substance: Any substance that may cause bodily injury, illness or death to a person or harm the environment.

c. Oil: Oil of any kind or in any form. It includes, but not limited to petroleum, fuel oil, oil sludge, oil refuse and oil mixed with wastes.

d. AFFF: Aqueous film-forming foam is synthetic fire suppression material. Although generally considered nontoxic and biodegradable, spills/releases of AFFF must not discharge into storm drains or waterways because of possible deleterious effects upon aquatic life. An AFFF release may be hazardous/toxic if it contains fuel, oil, or chemicals from a fire suppression effort.

e. On-Scene Commander (OSC): The OSC is the base official authorized to coordinate and direct base spill response activities. The 9th Combat Support Group Commander or the base Civil Engineer is the OSC. During initial response, the responding Fire Team Leader is the OSC, until relieved by the Group Commander or Civil Engineer, as appropriate.

f. Potential Spill Site: Any site where a hazardous substance could, during a 24-hour period, have a spill of sufficient magnitude to be a reportable quantity.

g. Release: Any spilling, leaking, pumping, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing of a hazardous substance into the environment. Exceptions are:

(1) Normal exposure to persons in a work place.

(2) Emissions from engine exhaust of motor vehicles, rolling stock, aircraft, vessels or pipeline pumping station engines.

(3) Normal application of fertilizers.

h. Reportable Quantity: A hazardous substance spilled into the environment that requires reporting to federal spill networks.

(1) A reportable quantity of oil is an oil discharge that will:

(a) Result in violation of applicable water quality standards.

(b) Cause a film or sheen on, or discoloration of, the water or adjoining shorelines.

(c) Deposit a sludge or emulsion beneath the surface of the water or on adjoining shorelines.

(2) Reportable quantities of hazardous substances (other than oil) are listed in 40 Code of Federal Regulations (CFR), Parts 117 and 302. Quantities are listed in pounds and kilograms, generally requiring conversion to gallons or liters when liquids are involved. For a spill of a liquid chemical or pesticide, after making appropriate emergency notifications, contact 9 CSG/DEEV for assistance in determining if a reportable quantity in involved. The quantities are those released within a 24 hour period. NOTE: Reportable quantities in 40 CFR 117 and 302 are in increments of 1, 10, 100, 1000, and 5000 pounds; and are primarily comprised of chemicals and pesticides that would be considered toxic or harmful if spills/releases were not controlled/contained. Federal law requires that releases of reportable quantities be reported to responsible agencies, which for Beale AFB are given in AFR 19-8, and SAC and BAFB supplements thereto. Spill reporting, if necessary, will be accomplished by 9 CSG/DEEV after coordination and approval of 9 SRW/CC.

i. Spills: Spills are reported as minor, medium, or major discharges.

(1) A minor discharge is less than 1000 gallons of oil into inland waters. It includes any hazardous substance that is less than a reportable quantity.

(2) A medium discharge is 1000 to 10,000 gallons of oil into inland waters. It includes any hazardous substance that is equal or more than a reportable quantity.

(3) A major discharge is more than 10,000 gallons of oil into inland waters. Also, a major discharge of a hazardous substance is one that poses a substantial threat to the public health or welfare, or results in critical public concern.

j. Site Specific Spill Plan: A plan made for a potential spill site. It meets EPA standards and requirements listed in 40 CFR 112.

k. Spill Prevention and Response Plan: The Oil and Hazardous Substance spill prevention and response plan combined with the requirements of various federal laws.

5. ENVIRONMENTAL PROTECTION COMMITTEE RESPONSIBILITIES (EPC). Manage the base spill prevention and response activities. Appoint appropriate working groups, as necessary, to oversee and scrutinize the base spill response capability. Reviews spill incidents, spill prevention measures, and response deficiencies with the goal of precluding environmental damage at Beale AFB.

6. ORGANIZATIONAL RESPONSIBILITIES. Identify presence, location, and quantities of all oil and hazardous substances they handle, treat, or store. Designate locations as potential spill sites that have potential for release of oil and hazardous substances in reportable quantities to the environment. Reduce the potential sites to the minimum needed for efficient and environmentally sound operations.

a. Make a spill plan for each site. Upgrade each site to meet requirements for physical construction, equipment, and procedures.

b. Be sure people are properly trained in all spill prevention and response program requirements. Develop procedures and make sure workers are trained to safely clean-up leaks and small spills that do not need special teams.

c. Designate an Organizational Environmental Coordinator and/or the EPC member as the point of contact for spill prevention and response matters.

7. 9 COMBAT SUPPORT GROUP COMMANDER (9 CSG/CC) RESPONSIBILITIES. The 9 CSG Commander is the primary OSC for the base. The OSC ensures spill prevention and response forces are properly manned, equipped, trained, and exercised. The OSC commits base disaster preparedness resources and coordinates with 9 SRW/CC to request off-base resources help. Approves and coordinates with 9 SRW/CC on all off-base spill reports required by AFR 19-8.

8. BASE CIVIL ENGINEERING SQUADRON (9 CSG/DE) RESPONSIBILITIES. Is the alternate OSC for the base. Monitors pollution abatement and spill prevention and response matters. Prepares off-base spill reports.

a. Designates the Engineering and Environmental Planning Branch (9 CSG/DEE) to:

(1) Give technical expertise to base organizations about spill prevention and response requirements and procedures.

(2) Monitor spill incidents.

(3) Accumulate data in required format for off-base reports in accordance with AFR 19-8 and AFR 19-8/BAFB Sup 1.

(4) Keep a log of reportable spills including reports, investigations, and corrective actions.

b. Designates the Fire Protection Branch (9 CSG/DEF) to:

(1) Act as the 24-hour spill reporting center.

(2) Provide spill response and containment capability by training and equipping fire department personnel to function as the base spill response team (see Atch 3).

(3) Keep operating instructions, alert rosters and logs to support the responsibilities assigned above. Obtain appropriate spill response and containment information including, but not limited to, the Coast Guard Chemical Hazards Response Information Systems (CHRIS) manuals, Department of Transportation Emergency Response Guidebook, and State of California spill response and reporting guidance.

(4) Negotiate and keep mutual aid and fire protection agreements with local fire districts and other fire agencies (Atch 2).

(5) Ensure that spill information and response data are properly recorded and reported to 9 CSG/DEEV and other involved base agencies. Provide information in writing (on forms provided by 9 CSG/DEEV) giving details of spill responses, quantities involved, etc.

c. Designates the Operations Branch (9 CSG/DEM) to:

(1) Provide backup equipment and resources to assist the 9 CSG/DEF spill response team at the request/order of the OSC.

(2) Give information and instruction to the wastewater treatment plant operators for any spills that may enter the base sanitary sewer system.

(3) Ensure the base exterior electric shop personnel (9 CSG/DEME) are equipped and trained to respond to electrical equipment PCB-oil leaks/spills.

9. 9th SECURITY POLICE RESPONSIBILITIES. Respond to spill notifications as part of the Initial Response Force; isolate the spill-area and control traffic in the area. Provides security checks of designated oil and hazardous substance storage areas while on normal patrol. If a leak or spill is discovered, notify the Base Fire Department.

10. 9th STRATEGIC HOSPITAL (9 STRAT HOSP/SG) RESPONSIBILITIES. Dispatch medical personnel and ambulance(s) to the site of the spill, when directed by the OSC; render emergency treatment; take injured people to the base hospital or nearest medical facility for treatment and give data to the OSC on the injured, as soon as possible.

11. BIOENVIRONMENTAL ENGINEERING SERVICES (9 STRAT HOSP/SGPB) RESPONSIBILITIES. Respond to spill notifications as part of the Initial Response Force; give technical assistance and advice to the OSC regarding hazards, environmental quality standards and criteria, and personal protective equipment; provide sampling and analysis as required through the Occupational and Environmental Health Laboratory (OEHL) or contract laboratories for testing and analysis.

12. BASE DISASTER PREPAREDNESS OFFICE (9 CSG/DW) RESPONSIBILITIES. Dispatch a representative with the Mobile Command Post to the site of the spill, when requested by the OSC.

13. TRANSPORTATION SQUADRON RESPONSIBILITIES (9 SRW/LGT). Give the OSC and emergency response forces priority transportation when needed.

14. STAFF JUDGE ADVOCATE (9 CSG/JA) RESPONSIBILITIES. Advise the OSC on the legal aspects of spill prevention, reporting and response; ensure information, photos, records and samples are adequate for legal purposes and safeguarded for future use.

15. OFFICE OF PUBLIC AFFAIRS (9 SRW/PA) RESPONSIBILTIES. Keep abreast of all base actions during a spill. Give prompt and accurate news releases on spill status; clear all news releases involving base actions with the OSC or designated representative.

16. WEATHER SQUADRON RESPONSIBILITIES. Provide toxic corridor information for spills that may emit toxic fumes.

17. POTENTIAL SPILL SITE REQUIREMENTS. The type and quantity of substances determine the site requirements:

a. Spill Control and Countermeasure Plans (SCCP) are required for certain oil sites. The sites generally need secondary containment and security. EPA regulations (40 CFR 112) require SCCP (certified by a registered professional engineer) for the following sites:

(1) Underground storage of more than 42,000 gallons.

(2) Above ground storage of more than 1,320 gallons and above ground single container of more than 660 gallons.

(3) Bulk loading and unloading facilities and vehicles and railroad cars used for transporting or storing oil on base.

b. Contingency plans are required for all oil and hazardous substance sites having the potential for releasing reportable quantities into the environment; also for sites with hazardous waste operations. Sites or facilities that utilize an AFFF fire suppression system must have a spill plan and a capability to contain AFFF runoff or to divert runoff to the sanitary sewer system.

18. SITE SPECIFIC SPILL PLAN PROCEDURES. A plan must be prepared for each potential spill site. Use a recommended site specific plan format available from 9 CSG/DEEV. Complex sites may require expanded format to accommodate chemical listings, site details and procedures. The following organizations will submit site specific spill plans:

a. 9 SRW/MA (9 AMS, 9 FMS, 9 OMS).

b. 9 SRW/IN (9 RTS, 9 SRW/SRA).

c. 9 SRW/RM (9 Supply SQ, 9 Transportation SQ).

d. 9 CSG/DE (DEM, DEF).

e. 7 Missile Warning Squadron.

f. 1883 Communications Squadron.

g. AAFES (BX, Commissary, Service Stations).

h. 9 SRW/LGSD (Material Storage & Distribution).

19. SPILL DISCOVERY AND SPILL RESPONSE PROCEDURES. Persons discovering a spill should immediately alert people in the area of a hazard. Notify the spill reporting center (Atch 4) and proceed with site-specific actions designated in the spill plan. Attachment 4 gives guidance for spill reporting and actions to take. Include these procedures in training and orientation programs. All personnel must be aware of their responsibilities.

20. ON-BASE SPILL RESPONSE PROCEDURES. Make initial notification of a spill discovery to the Fire Protection Branch (9 CSG/DEF) dispatcher. After spill discovery notification has been made, the following events occur as applicable:

a. 9 CSG/DEF spill team responds.

b. 9 CSG/DEF dispatcher notifies 9 CSG/SP and 9 STRAT-HOSP/SGPB that spill response is in progress. 9 CSG/DEF, 9 CSG/SP, 9 STRAT HOSP/SGPB form the Initial Response Force with functions and composition indicated in Atch 3.

c. 9 CSG/DEF dispatcher notifies 9 CSG/DE and 9 CSG/DEM service call desk that a spill response is in progress.

d. The 9 CSG/DEF team leader directs 9 CSG/DEF dispatcher to notify 9 CSG/DE and 9 CSG/DEM service call desk when and if the spill is contained, controlled, or terminated by Initial Response Force and/or responsible agency.

e. The 9 CSG/DEF team leader directs 9 CSG/DEF dispatcher to begin notification of additional resources if spill exceeds immediate capabilities of the Initial Response Force.

f. In the event of para 20e above, 9 CSG/DEF dispatcher requests OSC and/or 9 CSG/DE to respond. 9 CSG/DEF notifies local mutual aid resources, if required. See Attachment 2 for outside resources and Attachment 3 for Emergency Response Team functions and composition.

g. OSC directs initiation of remote containment and treatment procedures if spill entered or is in danger of entering a storm drain or sanitary sewer or base waterways.

h. 9 STRAT HOSP/SGPB samples and tests for pollutants, following procedures of 40 CFR 1510, Annex VI. Safeguard and document samples and results for future use.

i. 9 CSG/DE compiles data for off-base notifications per AFR 19-8 and AFR 19-8/BAFB Sup 1, after initial spill evaluation. 9 SRW/CC will approve all reports/messages prior to release.

j. The OSC decides when the spill is contained and threat is eliminated. OSC turns cleanup and restoration actions over to the responsible party. Cleanup of chemicals needing special teams and equipment will be done by Spill Response Team or outside resources.

k. Cleanup, disposal and restoration is done by the responsible agency, under surveillance of an OSC representative.

l. The OSC approves corrective actions and follow-up reports.

21. OFF-BASE SPILL RESPONSE PROCEDURES. Make initial notification of off-base spill discoveries to the Spill Reporting Center (see Atch 4). Make the second notification to the Command Post (9 SRW/DOC). After initial spill discovery notification has been made, the following events occur, as applicable:

a. The local fire department or emergency team responds.

b. 9 SRW/DOC notifies the 9 SRW/CC, 9 CSG/CC, 9 CSG/DE, and other staff agencies, as directed by the Wing Commander.

c. The OSC proceeds with designated staff to direct containment, cleanup and restoration activities.

e. 9 SRW/PA coordinates news releases with OSC, 9 CSG/JA, 9 CSG/DE and obtains 9 SRW/CC approval before release.

f. Sequence of events in paragraph 20 "i" through "l" apply.

22. TRAINING REQUIREMENTS. Organizational commanders, functional managers and supervisors will provide employees with required training. Get technical guidance from safety, medical services, fire protection and environmental planning offices.

a. Spill prevention and response training will have the following program elements:

(1) A new employee training program and a supervisor training program.

(2) Annual refresher training and periodic briefings on changes in procedures, equipment, and requirements.

(3) Specialized training programs for Fire Department spill response team.

b. Train personnel in the following:

(1) Properties and potential hazards of substances in the work place.

(2) Use of personal protective equipment needed for the job.

(3) Specific procedures for the work place to include spill discovery and notification, use of emergency equipment and spill cleanup materials. Cite procedures for inspections, housekeeping, evacuation procedures and location of spill plan and chemical data sheets.

c. 9 CSG/DEEV will compile a list of known on- and off-base spill prevention and response training courses. They will distribute them periodically to assist unit commanders, functional managers, and supervisors with their training programs.

FOR THE COMMANDER

HEADQUARTERS 9TH COMBAT SUPPORT GROUP (SAC) OFFICIAL

LAURIE F. FORTENBERRY, Captain, USAF
Chief, Base Administration

4 Atch
1. Installation Drainage Map.
2. Outside Resources Available to Assist with Hazardous Materials Spill Incidents.
3. Beale AFB Spill Response Functions and Resources.
4. Procedures for Individuals Discovering a Spill.

SUMMARY OF CHANGES: Responsibility for spill response team changed from 9 CSG/DEM to 9 CSG/DEF; description of reportable quantities expanded; provision for the base spill committee deleted; discussion of required signs deleted; hazardous waste accumulation point checklists deleted.

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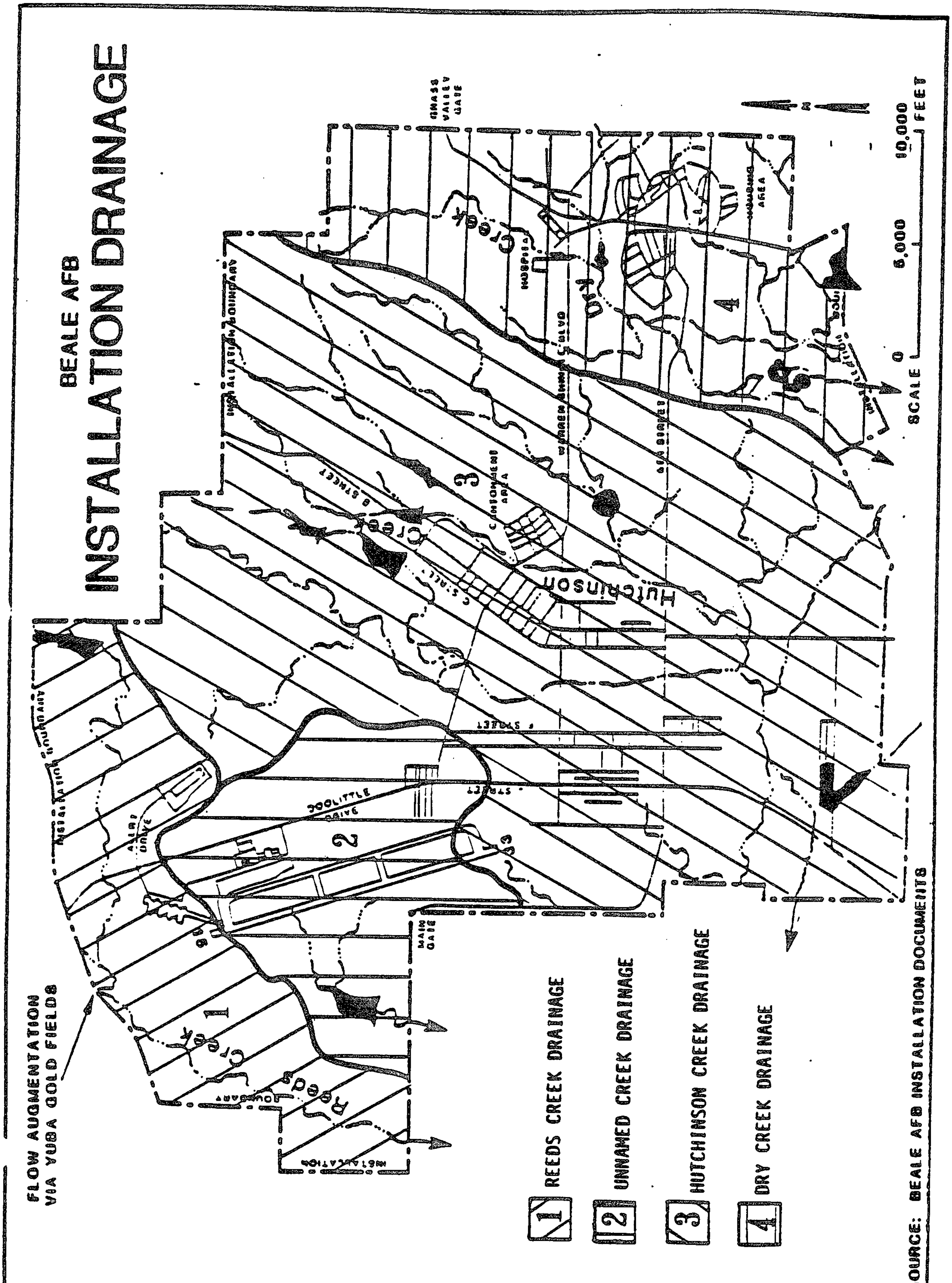
BEALE AFB
INSTALLATION DRAINAGE
FLOW AUGMENTATION VIA YUBA GOLD FIELDS
Reeds Creek
Hutchinson
Creek
MAIN GATE
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C STREET
CANTONMENT AREA
WARREN SHINGLE BLVD
HOSPITAL
INSTALLATION BOUNDARY
SCALE
0 5,000 10,000 FEET
N
1 REEDS CREEK DRAINAGE
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3 HUTCHINSON CREEK DRAINAGE
4 DRY CREEK DRAINAGE
SOURCE: BEALE AFB INSTALLATION DOCUMENTS

OUTSIDE RESOURCES AVAILABLE TO ASSIST WITH HAZARDOUS MATERIALS SPILL INCIDENTS

1. MUTUAL AID AGREEMENTS. Mutual Aid and Fire Protection Agreements are in effect with the agencies indicated below:

Wheatland Fire Department
Marysville Fire Department
Yuba City Fire Department
Linda Fire Department
California State Forestry Department, Smartsville Fire Station
Olivehurst Fire Department
Walton Fire Department
Plumas Brophy Fire Department

2. YUBA-SUTTER AREA SPILL RESPONSE. Neither Yuba County nor Sutter County has established a spill response team. Both counties have plans and personnel to respond to pesticide incidents through their respective agricultural departments; otherwise, both counties rely on area fire departments. The Marysville and Yuba City Fire Departments have little equipment, but have some firefighters trained in spill response and cleanup. These fire departments might enhance manpower for a spill response at Beale, but could add little actual equipment.

3. CHEMICAL TRANSPORTATION EMERGENCY CENTER. The Chemical Transportation Emergency Center has a 24-hour hotline. It gives warnings and limited guidance to the OSC, when a spill product can be identified by either chemical or trade name. The center assists the OSC in contacting the manufacturer or shipper for additional information. Use this service when adequate spill response information is not available. Their telephone number is 1-800-424-9300.

4. EMERGENCY CONTRACTS. If spill containment or cleanup exceeds the capabilities of in-house and mutual aid resources, an emergency contract may be feasible.

a. For an emergency contract, 9 CSG/DE estimates the requirement, verifies availability of funds and identifies a qualified contractor. The base Contracting Division (9 SRW/LGC) negotiates with the contractor and awards an oral contract. 9 CSG/DE will prepare a purchase request on the next work day.

b. Contractors available on short notice:

AMERICAN ENVIRONMENTAL MANAGEMENT CORPORATION
EPA ID NO. CAD067825364
24-hour dispatch phone number: (916) 985-6666
Capabilities: Contain and cleanup most hazardous materials
Laboratory services
1-2 hour response time

I. T. CORPORATION
EPA ID NO. CAD0000 83121
24-hour dispatch phone number: (415) 228-5100 (Martinez CA)
Capabilities: Contain and cleanup most hazardous materials, except pressure vessels
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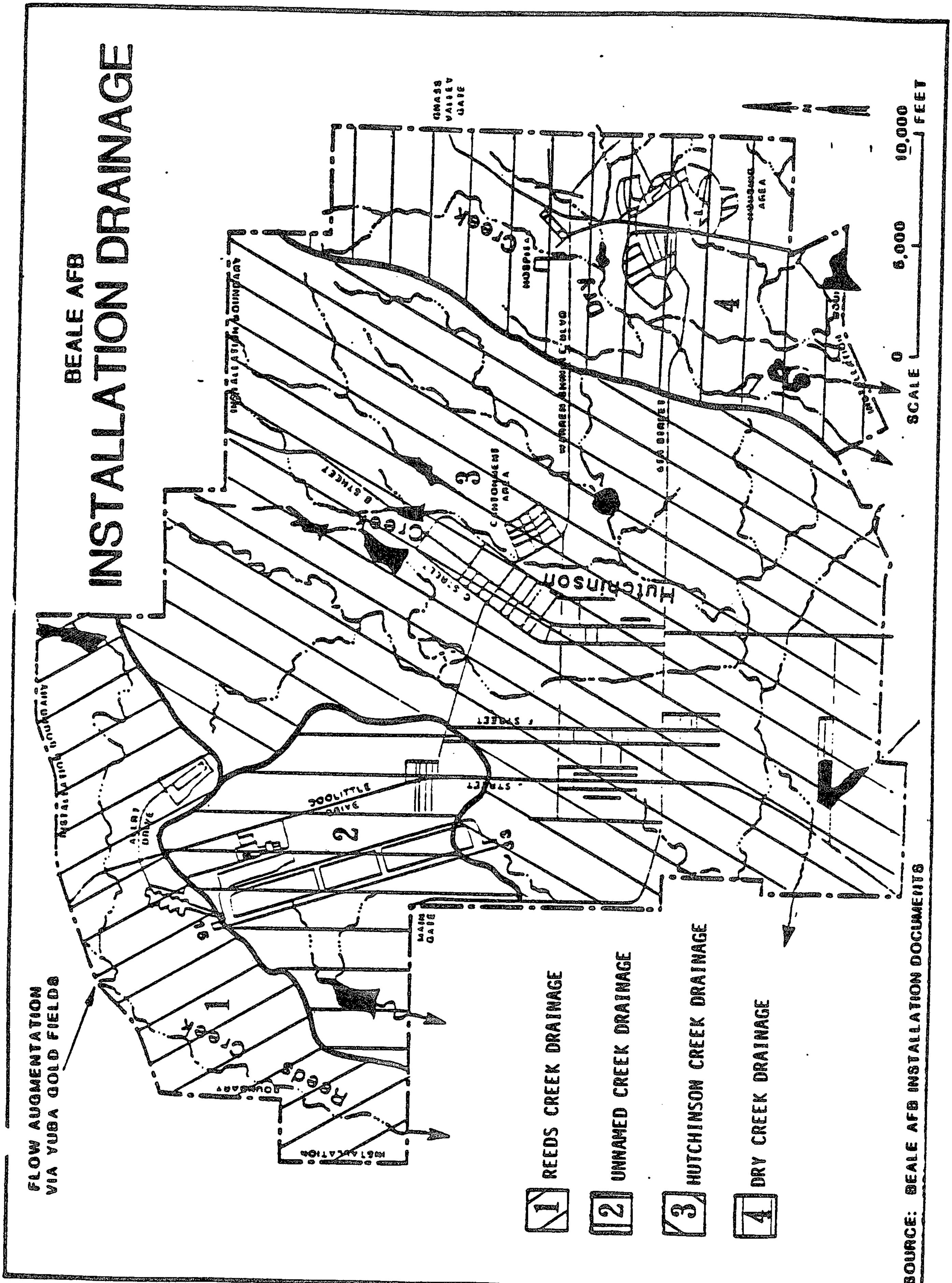
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3-4 hour response time

BEALE AFB SPILL RESPONSE FUNCTIONS AND RESOURCES

1. 9 CSG/DEF INITIAL SPILL RESPONSE FUNCTIONS. Responds to notifications of a spill or imminent spill. Performs rescue and fire suppression. Decides the type and quantity of chemicals spilled, and actual or potential hazards. Decides actions and resources needed to protect people and property. Requests additional resources, if needed (see Atch 2). Establishes on-scene control. All responding personnel will first report to Fire Team leader for directions as to personnel protective clothing, and the best route to the spill site, to ensure minimum exposure.

2. SPILL RESPONSE FORCE AVAILABLE RESOURCES.

PERSONNEL AVAILABLE

One Assistant Fire Chief (Initial OSC)
Rescue Crew (3 people)
Pumper Crew (4)
One Bioenvironmental Engineer
One Security Police Unit

EQUIPMENT AVAILABLE

3 crash trucks (2P-2, 1P-15)
One rescue truck
Three structural rigs
1500 gallon tanker
33 Self-contained breathing apparatus.
2 full encapsulated chemical suits
One combustible gas detector
One sampling kit
One security police vehicle

3. 9 CSG/DEF SPILL RESPONSE TEAM FUNCTIONS. Responds to requests from the Fire Team Leader or OSC for containment, decontamination and cleanup resources. Gives emergency containment and decontamination beyond the capabilities of the agency responsible for the spill. The team seals off source of spill. Builds temporary containment (dikes, berms, etc.) and applies absorbents. Activates remote containment facilities when appropriate. The team returns cleanup and restoration activities to the agency responsible for the spill when conditions permit.

RECOMMENDED EQUIPMENT

1 spill trailer (shovels, brooms, squeegees, tarp, bags, overpack drum, absorbent, drum sling, manhole device, and so on)

6 each sets of protective clothing (self-contained breathing apparatus, chemical suits, gloves, boots, and eye protection)

One flatbed truck

One dump truck

One forklift

One ground power unit with portable lights

One gasoline-powered pump and hoses

100 bags of absorbent

200 filled sandbags

One mercury vacuum and kit

One hazardous material repair kit for small containers

One hazardous material repair kit for large containers

One acid spill kit

Two 40lb packs of imbiber beads

Two 3' x 150' sorbent rolls

One package of sorbent pillows

Four sorbent booms

PROCEDURES FOR INDIVIDUALS DISCOVERING A SPILL

1. KNOW WHEN TO REPORT A SPILL.

a. Report all spills of extremely or highly flammable materials (National Fire Protection Association (NFPA) flammability scale of 3 or 5) in excess of one gallon. Examples are alcohols, naptha, gasoline and acetone.

b. Report all spills of hazardous materials which cannot be safely and readily contained and cleaned up using on-site spill equipment and trained people.

c. Report all spills of hazardous materials which enter or threaten to enter waterways or drains.

d. Report all spills which are obviously a fire hazard or a threat to human health or the environment.

f. Report all continuous flowing spills of any materials.

2. ACTION TO TAKE.

a. Alert personnel. Evacuate area if applicable.

b. Notify your Spill Reporting Center (see paragraph 3 below).

c. Take actions in site specific spill plan in conjunction with the following actions: Stop the source of spill. Contain it when possible, without undue risk of personal injury. Make spill scene off-limits to unauthorized personnel. Restrict all sources of ignition when flammable substances are involved. Report to responding Fire Team leader or the On-Scene Commander and give assistance if requested.

3. KNOW THE APPROPRIATE SPILL REPORTING CENTER.

LOCATION	SPILL REPORTING CENTER	TELEPHONE NUMBER
On Beale AFB	Beale Fire Department	117 or 634-2117
Off-Base on State and County Roads	Highway Patrol and Beale Command Post (if spill is responsibility of Beale or DoD agency)	Dial "0", ask for Zenith 1-2000 (Highway Patrol) 634-2508 (Beale Command Post)
Off-Base in county or city	City Police Department or County Sheriff and Beale Command Post (if spill responsibility of Beale or other DoD agency)	911 634-2508 (Beale Command Post)

4. INFORMATION TO REPORT.

a. Your name.

b. Location of spill (building number, grid location, street and so on).

c. Number of injured people and nature of injuries, if applicable.

d. Substances spilled, if known.

e. Estimated amount spilled.

f. Extent of spill (contained, entering storm drain, and so forth).

g. Time spill occured, if known.

h. Other agencies notified.

i. Other pertinent information.

APPENDIX E

RISK ASSESSMENT RESULTS
(Law Environmental Report)

LAW ENVIRONMENTAL

CONTRACTOR CONTRACT NO. 11-1534
DELIVERY ORDER NO. 0002

INSTALLATION RESTORATION PROGRAM (IRP) PRELIMINARY ASSESSMENT AND REMEDIAL INVESTIGATION STAGE 3.0

EXPOSURE ASSESSMENT

BEALE AIR FORCE BASE
MARYSVILLE, CALIFORNIA

LAW ENVIRONMENTAL, INC.
GOVERNMENT SERVICES BRANCH
114 TOWNPARK DRIVE
KENNESAW, GA 30144

October 1992

PREPARED FOR:

Headquarters Air Combat Command
HQ ACC/DE
Langley Air Force Base, Virginia

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
IRP PROGRAM OFFICE (AFCEE/ESR)
BROOKS AIR FORCE BASE, TEXAS 78235-5000

1534.23

LAW ENVIRONMENTAL, INC.

GOVERNMENT SERVICES BRANCH
114 TOWNPARK DRIVE, 4TH FLOOR
KENNESAW, GEORGIA 30144-5508
404-499-6800

October 7, 1992

AFCEE/ESR
Attention: Captain John Coho
Contract No. F33615-90-D-4008/Order No. 0002
Building 646 West
Brooks AFB, TX 78235-5000

Subject: Exposure Assessment
Preliminary Assessment and Remedial Investigation, Stage 3.0
Beale Air Force Base, California

Dear Captain Coho:

Law Environmental, Inc. is pleased to submit the Exposure Assessment for the subject project. This report was prepared to fulfill the requirements of Sections 1.5.14 and Item VI, Sequence No. 16, Paragraph 6.1 of the Statement of Work.

If you have any questions or comments regarding this Exposure Assessment, please do not hesitate to contact either George Wessman (916/649-2424) or Lee Ann Smith (404/499-6826).

Sincerely,

for

George L. Wessman, P.E.
Project Manager

Lee Ann Smith
Principal

LAS:mlh

cc: Ms. Sherri Rolfsness, Beale AFB (with enclosures)
Ms. Sharon Hrabovsky, Modern Technologies (with enclosures)
Ms. Geraldine Shannon (without enclosures)

1534.25

INSTALLATION RESTORATION PROGRAM (IRP)
PRELIMINARY ASSESSMENT AND REMEDIAL INVESTIGATION
STAGE 3.0

EXPOSURE ASSESSMENT

FOR

BEALE AIR FORCE BASE

HEADQUARTERS AIR COMBAT COMMAND
HQ ACC/DE
LANGLEY AIR FORCE BASE, VIRGINIA

October 1992

PREPARED BY

LAW ENVIRONMENTAL, INC
GOVERNMENT SERVICES BRANCH
114 TOWNPARK DRIVE
KENNESAW, GA 30144

USAF CONTRACT NO. F33615-90-D-4008, DELIVERY ORDER NO. 0002
CONTRACTOR CONTRACT NO. 11-1534, DELIVERY ORDER NO. 0002

Air Force Center for Environmental Excellence
(AFCEE-ESO/ERT)
Captain John Coho
Contracting Officer's Technical Representative

IRP PROGRAM OFFICE (AFCEE/ESR)
BROOKS AIR FORCE BASE, TEXAS 78235-5000

TABLE OF CONTENTS

SECTION

1.0 INTRODUCTION

Beale Air Force Base (AFB) is an active United States AFB which serves as an Air Combat Command (ACC) base and is located in north central California. Previous Installation Restoration Program Studies at the base have identified soils contaminated with hydrocarbon fuels (CH_2M, Hill, 1991). A biodegradation process is planned to remediate these soils. This exposure assessment and screening health risk assessment (SHRA) was performed to evaluate potential exposures and human health risks associated with treatment of hydrocarbon-containing soils using the biodegradation process described in the following sections.

1.1 Project Description

Leaking underground storage tanks and other sources have resulted in soils contaminated with fuel hydrocarbons at Beale AFB. The fuels include gasoline, diesel, JP-4, and heating oils. Sampling to date indicates diesel is the primary contaminant, with soil concentrations ranging from below detection limits up to 8200 mg/kg. Benzene, toluene, ethylbenzene and xylene (BTEX) have been detected in the soils.

The United States Air Force (USAF) intends to treat the fuel hydrocarbon-containing soils present at Beale AFB, referred to as feedstock soils, using a biodegradation process (Biofilter). Briefly, this process is accomplished by piling feedstock soils on the ground around a piping manifold and covering the mound with plastic. Hydrocarbon constituents are removed by drawing metered quantities of air through the piles. The resulting hydrocarbon vapor-containing air is then passed thorough a biofilter, consisting of a treatment soil pile where water and nutrients are continuously added to promote biodegradation activity. As the air is passed through the treatment pile, hydrocarbons in the vapor phase are adsorbed onto the soil particles where biodegradation occurs. The quantity of air passed through the system is closely controlled to achieve a high degree of adsorption and biodegradation. The treated air is released to the atmosphere through a single vent.

1.2 Purpose

Because the proposed treatment process may comprise a source of hydrocarbon emissions, an Authority To Construct (ATC) and Permit To Operate (PTO) must be obtained from the Feather River Air Quality Management District (District) prior to operation. To issue the permits, the District must determine that there is no significant human health risk posed by the project. Thus, this study presents an evaluation of potential human health risks to support the District's determination.

1.3 Approach

To evaluate potential health risks, a screening approach that generally follows the methodology for screening assessments provided in the "Air Toxics Hot Spots Program Risk Assessment Guidelines" (CAPCOA, 1992) is used and supplemented with guidelines from "Risk Assessment Guidance For Superfund Human Health Evaluation Manual" (USEPA, 1989).

Of the compounds previously detected in soils (benzene, toluene, ethylbenzene and xylene), only benzene has been classified by the USEPA as a known human carcinogen (weight of evidence = A; IRIS, 1992). Toluene, ethylbenzene and xylene have weight of evidence classifications of D, indicating there are no known studies suggesting that these compounds are carcinogenic (IRIS, 1992). For this reason, only benzene was evaluated for carcinogenic risk. Toluene, ethylbenzene and xylene have been evaluated by the USEPA for non-carcinogenic adverse health effects. These are expressed as acute and chronic reference doses. These three compounds have been evaluated in this exposure assessment for non-carcinogenic health effects. Because benzene has no published reference dose, it was not included in the non-carcinogenic health assessment.

Because the soil piles will be covered, the sole exposure pathway evaluated in this study is the inhalation of vapors emitted from the exhaust vent. Air dispersion modeling is used to determine ambient air concentrations. Intermittent exposures to workers, as well as to continuously exposed receptors, are evaluated. The criteria used by USEPA to determine

significant cancer risk is an excess lifetime cancer risk of more than one in one-million. Significant non-carcinogenic risk is determined to be an ambient concentration greater than acceptable exposure levels established by regulatory agencies.

2.0 EMISSION ESTIMATES

Emissions of benzene, toluene, ethylbenzene, and xylene (BTEX) are roughly projected for this study using conservative (high) assumptions of operating characteristics based on prior experience for projects of this type. Emission rates will depend on a number of factors including: soil characteristics (e.g., contaminant concentration, porosity, moisture, organic content) and process characteristics (e.g., air flow rate, water and nutrient addition rates, amount of soil treated). Biofiltering has proven to be an effective cost-efficient remediation technology achieving high degrees of contaminant removal. However, each application is optimized around the on-site conditions. For the current application, emissions are estimated based on:

- a preliminary maximum design air flow rate of 1,000 actual cubic feet per minute (acfm)
- a maximum volatile organic compound (VOC) concentration at the exhaust of 1,000 parts per million by volume (ppmv)
- a maximum BTEX concentration of 10 percent (10 ppmv)
- a maximum benzene concentration of 1 percent (1 ppmv)

Emission rates are calculated by multiplying the concentration of the compound by the volume of air flow. Emissions for the compounds of interest are calculated as shown below.

Benzene:

$$\begin{aligned} B &= 1.0\ ft^3\ B / 10^6\ ft^3\ air \times 1{,}000\ ft^3\ air/min \times 78.1\ lb\ B / 379\ ft^3\ B \\ &= 0.00021\ lb/min\ \ (or\ 1.59\ mg/s) \end{aligned}$$

Remaining BTEX fraction:

$$\begin{aligned} TEX &= 9.0\ ft^3\ TEX / 10^6\ ft^3\ air \times 1{,}000\ ft^3\ air/min \times 100\ lb\ TEX / 379\ ft^3\ TEX \\ &= 0.00237\ lb/min\ (or\ 17.9\ mg/s)\ (assumes\ avg\ mol\ wt\ of\ 100\ lb/lbmol) \end{aligned}$$

3.0 EXPOSURE ASSESSMENT

3.1 Receptor Identification

Potential human receptors for exposure to vapors are limited due to the project's location on Beale AFB, which is secured from the general public. The only potential receptors are personnel working at the bioventing project and personnel at the Correctional Custody Facility which is located approximately 250 meters southeast from the bioventing stack. Personnel working at the bioventing site will be evaluated for exposure during working hours, while personnel at the Correctional Custody Facility are evaluated for continuous exposure.

3.2 Dispersion Modeling

Dispersion of vapors in air and resulting ambient air concentrations were projected using the USEPA Industrial Source Complex - Short Term Version 2 (ISCST2) model. This model was selected as appropriate according to the models approved for this type of application by the California Air Pollution Control Officers' (CAPCOA; 1989, 1992). The area surrounding the project is rural and without significant terrain features and buildings that could affect plume dispersion. Ambient concentrations were calculated at receptor locations set at distances directly downwind from the stack at 25 meters (m), 50m, 75m, 100m, 150m, 200m, 250m, 300m, 400m, 500m, 750m, 1000m, 1500m, 2000m, and 3000m. Stack parameters input to the model are based on preliminary design considerations: stack height = 10 ft, stack diameter = 4 inches, exhaust temperature = 298°K (ambient), and volumetric flowrate = 1000 cfm. A nominal emission rate of 1 mg/s was input to the model to facilitate calculation of concentrations at different emission rates without having to re-run the model (concentrations are directly proportional to emission rate). A variety of hypothetical one-hour meteorological conditions combining wind speed and stability class were studied to provide a worst-case analysis. A complete listing of input data is provided in Appendix A on the computer printouts.

Maximum concentrations from the model are one-hour maximums and are adjusted to long-term (annual average) concentrations by multiplying by 0.10 (CAPCOA, 1989; BAAQMD, 1988).

The maximum one-hour concentration was found to be 5.92 ug/m^3 per mg/s of emissions occurring at a downwind distance of 50 meters under meteorological conditions of C stability and 1.0 m/s wind speed. When multiplied by 0.1, the annual average concentration is 0.592 ug/m^3 per mg/s. At a distance of 250 meters downwind, corresponding to the Correctional Custody Facility, the annual average concentration is estimated to be 0.297 ug/m^3 per mg/s. Annual concentrations further downwind drop to two percent of the maximum at a downwind distance of three kilometers. Ambient concentrations of benzene and TEX are calculated by multiplying the nominal concentrations by the true emission rates as shown below.

	Emission	Nominal Annual Conc. (ug/m^3 per mg/s)		Annual Ambient Conc. (ug/m^3)	
Component	Rate, mg/s	50 m	250 m	50 m	250 m
Benzene	1.59	0.592	0.297	0.941	0.472
TEX	17.9	0.592	0.297	10.6	5.32

4.0 RISK ESTIMATION

4.1 Carcinogenic Risk

Potential cancer risk due to benzene emissions is calculated based on a unit risk factor of 2.9 x 10^{-5} $(ug/m^3)^{-1}$ (CAPCOA, 1992). The unit risk factor is defined as the estimated probability of a person contracting cancer as a result of constant exposure to an ambient concentration of 1 ug/m^3 over a 70-year lifetime (CAPCOA, 1992). To determine the risk to workers who are exposed intermittently rather than continuously, and to persons who are exposed for less than a lifetime by a short-term project such as this soil remediation project, a frequency of exposure factor and project duration factor are included. The cancer risk due to benzene is calculated as shown below.

Risk = UR x C x F x D

where:

Risk	= cancer risk, probability
UR	= unit risk factor, m^3/ug
C	= annual average ambient air concentration, ug/m^3
F	= frequency of exposure factor, dimensionless
	= 1 for continuous exposures
	= 0.23 (= [8 hrs/day x 5 days/wk x 50 wks/yr] / 8760 hrs/yr)
D	= project duration factor, dimensionless
	= 0.071 (= 5 yrs / 70 yr lifetime)

For on-site workers subject to intermittent exposure, the risk is calculated to be:

$$\text{Risk} = 2.9\times10^{-5}\ m^3/ug \times 0.941\ ug/m^3 \times 0.23 \times 0.071$$
$$= 4.5\times10^{-7}$$

For persons at the Correctional Custody Facility which is 250 meters downwind from the source and subject to continuous exposure, the risk is calculated to be:

$$\text{Risk} = 2.9\times10^{-5}\ m^3/ug \times 0.472\ ug/m^3 \times 1.0 \times 0.071$$
$$= 9.7\times10^{-7}$$

Thus, cancer risk due to inhalation of benzene vapors from the biotreater exhaust vent are conservatively estimated to be less than one in one-million, and therefore, are not considered to pose a significant cancer risk.

4.2 Non-Carcinogenic Chronic Risk

Non-carcinogenic chronic risk is evaluated for toluene, ethylbenzene, and xylene by considering the assumption that all the TEX emissions are made up of the most hazardous compound. This assumption is made since the relative fractions of TEX cannot be known prior to system operation. A discussion of toxicity of these compounds is included in Appendix B and shows that the most hazardous compound is toluene which has the lowest chronic inhalation Acceptable Exposure Level (AEL) of 200 ug/m^3 (CAPCOA, 1992). Because the annual average ambient air concentrations of TEX are 10.6 ug/m^3 for worker exposures and 5.32 ug/m^3 for continuous exposures (250 m downwind), which are considerably less than the acceptable level of the most hazardous component, it is determined that chronic non-cancer risk due to TEX is within an acceptable exposure range as defined by CAPCOA (1992).

4.3 Non-Carcinogenic Acute Risk

The only compound reported to have acute non-carcinogenic effects is xylene, which has an acceptable exposure level of 4,400 ug/m^3 (CAPCOA, 1992). The short-term ambient air concentration of xylene is conservatively assumed for purposes of this risk assessment to be the maximum one-hour TEX concentration (106 ug/m^3 at 50 meters and 53.2 ug/m^3 at 250 meters). These concentrations are a small fraction of the acceptable exposure levels defined by CAPCOA (1992).

5.0 SUMMARY

The purpose of this exposure assessment is to evaluate potential risks of using a biodegradation process to remove hydrocarbons from contaminated soils at Beale AFB. The potential human receptors identified are site workers and personnel at the Correctional Custody Facility.

The results of this exposure assessment indicate that potential risks from the Biofilter process are within acceptable limits as defined by USEPA (1990) and CAPCOA (1992). The estimated carcinogenic risk for exposure to benzene at the Correctional Custody Facility is 9.7×10^{-7}, and the estimated non-carcinogenic risks for exposure to TEX are within acceptable exposure levels as defined by CAPCOA (1992).

6.0 REFERENCES

BAAQMD, 1988. "Permit Modeling Guidance" Bay Area Air Quality Management District, August 16, 1988, San Francisco, CA.

CAPCOA, 1989. California Air Pollution Control Officers Association. Toxic Air Pollutant Sources Assessment Manual for California Air Pollution Control Districts and Applicants for Air Pollution Control District Permits. October, 1987, revised December 1989.

CAPCOA, 1992. California Air Pollution Control Officers Association, AB2588 Risk Assessment Committee, Risk Assessment Guidelines, Air Toxics "Hot Spots" Program.

CH_2M HILL, 1991. Installation Restoration Program, Stage 2-1, Remedial Investigation, Final Report for Beale Air Force Base, California.

IRIS, 1992. Integrated Risk Information System. TOXNET Files. National Library of Medicine. U.S. Department of Health and Human Services. Public Health Service. National Institute of Health.

USEPA, 1989. United States Environmental Protection Agency. Risk Assessment Guidance for Superfund, Human Health Evaluation Manual, Part A, Interim Final. EPA/540/1-89/002.

USEPA, 1990. "National Contingency Plan", Federal Register, 55(46):8813-8865.

APPENDIX A

DISPERSION MODEL COMPUTER OUTPUT

ISCST Screening Meteorological Data

YYMODYHR	Flow Vector	Wind Speed	Temp	Stab	Mixing Height	
99999	90	99999		90		
90 1 1 1	90.0000	1.0000	293.0	1	5000.0	5000.0
90 1 1 2	90.0000	2.0000	293.0	1	5000.0	5000.0
90 1 1 3	90.0000	3.0000	293.0	1	5000.0	5000.0
90 1 1 4	90.0000	1.0000	293.0	2	5000.0	5000.0
90 1 1 5	90.0000	2.0000	293.0	2	5000.0	5000.0
90 1 1 6	90.0000	3.0000	293.0	2	5000.0	5000.0
90 1 1 7	90.0000	4.0000	293.0	2	5000.0	5000.0
90 1 1 8	90.0000	5.0000	293.0	2	5000.0	5000.0
90 1 1 9	90.0000	1.0000	293.0	3	5000.0	5000.0
90 1 110	90.0000	2.0000	293.0	3	5000.0	5000.0
90 1 111	90.0000	3.0000	293.0	3	5000.0	5000.0
90 1 112	90.0000	4.0000	293.0	3	5000.0	5000.0
90 1 113	90.0000	5.0000	293.0	3	5000.0	5000.0
90 1 114	90.0000	8.0000	293.0	3	5000.0	5000.0
90 1 115	90.0000	10.0000	293.0	3	5000.0	5000.0
90 1 116	90.0000	1.0000	293.0	4	5000.0	5000.0
90 1 117	90.0000	2.0000	293.0	4	5000.0	5000.0
90 1 118	90.0000	3.0000	293.0	4	5000.0	5000.0
90 1 119	90.0000	4.0000	293.0	4	5000.0	5000.0
90 1 120	90.0000	5.0000	293.0	4	5000.0	5000.0
90 1 121	90.0000	8.0000	293.0	4	5000.0	5000.0
90 1 122	90.0000	10.0000	293.0	4	5000.0	5000.0
90 1 123	90.0000	15.0000	293.0	4	5000.0	5000.0
90 1 124	90.0000	20.0000	293.0	4	5000.0	5000.0
90 1 2 1	90.0000	1.0000	293.0	5	5000.0	5000.0
90 1 2 2	90.0000	2.0000	293.0	5	5000.0	5000.0
90 1 2 3	90.0000	3.0000	293.0	5	5000.0	5000.0
90 1 2 4	90.0000	4.0000	293.0	5	5000.0	5000.0
90 1 2 5	90.0000	5.0000	293.0	5	5000.0	5000.0
90 1 2 6	90.0000	1.0000	293.0	6	5000.0	5000.0
90 1 2 7	90.0000	2.0000	293.0	6	5000.0	5000.0
90 1 2 8	90.0000	3.0000	293.0	6	5000.0	5000.0
90 1 2 9	90.0000	4.0000	293.0	6	5000.0	5000.0
90 1 210	90.0000	4.0000	293.0	5	5000.0	5000.0
90 1 211	90.0000	5.0000	293.0	5	5000.0	5000.0
90 1 212	90.0000	1.0000	293.0	6	5000.0	5000.0
90 1 213	90.0000	1.0000	293.0	6	5000.0	5000.0
90 1 214	90.0000	1.0000	293.0	6	5000.0	5000.0
90 1 215	90.0000	1.0000	293.0	6	5000.0	5000.0
90 1 216	90.0000	1.0000	293.0	6	5000.0	5000.0
90 1 217	90.0000	1.0000	293.0	6	5000.0	5000.0
90 1 218	90.0000	1.0000	293.0	6	5000.0	5000.0
90 1 219	90.0000	1.0000	293.0	6	5000.0	5000.0
90 1 220	90.0000	1.0000	293.0	6	5000.0	5000.0
90 1 221	90.0000	1.0000	293.0	6	5000.0	5000.0
90 1 222	90.0000	1.0000	293.0	6	5000.0	5000.0
90 1 223	90.0000	1.0000	293.0	6	5000.0	5000.0
90 1 224	90.0000	1.0000	293.0	6	5000.0	5000.0

NO ECHO

BEE-Line Max-32 Version 1.1

Input File - beale1.dta
Output File - beale1.lst
Met File - beale1.met

```
*************************************
*** SETUP Finishes Successfully ***
*************************************
```

```
*** ISCST2 - VERSION 92062 ***    *** LAW ENVIRONMENTAL - BEALE AFB PROJ#2-123-2567-01 BIOVENTING         ***      08/21/92
                ***                                                       ***      18:08:45
                                                                                   PAGE  1
*** MODELING OPTIONS USED:  CONC   RURAL  FLAT                                     NOCALM

                        ***     MODEL SETUP OPTIONS SUMMARY       ***
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

**Model Is Setup For Calculation of Average CONCentration Values.

**Model Uses RURAL Dispersion.

**Model Uses User-Specified Options:
        1. Final Plume Rise.
        2. Stack-tip Downwash.
        3. Buoyancy-induced Dispersion.
        4. Not Use Calms Processing Routine.
        5. Not Use Missing Data Processing Routine.
        6. Default Wind Profile Exponents.
        7. Default Vertical Potential Temperature Gradients.

**Model Assumes Receptors on FLAT Terrain.

**Model Assumes No FLAGPOLE Receptor Heights.

**Model Calculates  1 Short Term Average(s) of:   1-HR

**This Run Includes:    1 Source(s);      1 Source Group(s); and     15 Receptor(s)

**The Model Assumes A Pollutant Type of:  OTHER

**Model Set To Continue RUNning After the Setup Testing.

**Output Options Selected:
       Model Outputs Tables of Highest Short Term Values by Receptor (RECTABLE Keyword)

**Misc. Inputs:  Anem. Hgt. (m) =    10.00 ;    Decay Coef. =   0.0000     ;    Rot. Angle =     0.0
             Emission Units = (GRAMS/SEC)                    ; Emission Rate Unit Factor =   0.10000E+07
             Output Units   = (MICROGRAMS/CUBIC-METER)

**Input Runstream File: beale1.dta                 ;  **Output Print File: beale1.lst
**Detailed Error/Message File:   BEALE1.ERR
```

*** MODELING OPTIONS USED: CONC RURAL FLAT   NOCALM

*** POINT SOURCE DATA ***

SOURCE ID	NUMBER PART. CATS.	EMISSION RATE (USER UNITS)	X (METERS)	Y (METERS)	BASE ELEV. (METERS)	STACK HEIGHT (METERS)	STACK TEMP. (DEG.K)	STACK EXIT VEL. (M/SEC)	STACK DIAMETER (METERS)	BUILDING EXISTS	EMISSION RATE SCALAR VARY BY
1	0	0.10000E-02	0.0	0.0	0.0	3.00	298.00	5.82	0.10	NO	

*** MODELING OPTIONS USED: CONC RURAL FLAT NOCALM

*** SOURCE IDs DEFINING SOURCE GROUPS ***

GROUP ID	SOURCE IDs
ALL	1 ,

*** MODELING OPTIONS USED: CONC RURAL FLAT NOCALM

*** DISCRETE CARTESIAN RECEPTORS ***
(X-COORD, Y-COORD, ZELEV, ZFLAG)
(METERS)

```
(   25.0,    0.0,    0.0,    0.0);      (   50.0,    0.0,    0.0,    0.0);
(   75.0,    0.0,    0.0,    0.0);      (  100.0,    0.0,    0.0,    0.0);
(  150.0,    0.0,    0.0,    0.0);      (  200.0,    0.0,    0.0,    0.0);
(  250.0,    0.0,    0.0,    0.0);      (  300.0,    0.0,    0.0,    0.0);
(  400.0,    0.0,    0.0,    0.0);      (  500.0,    0.0,    0.0,    0.0);
(  750.0,    0.0,    0.0,    0.0);      ( 1000.0,    0.0,    0.0,    0.0);
( 1500.0,    0.0,    0.0,    0.0);      ( 2000.0,    0.0,    0.0,    0.0);
( 3000.0,    0.0,    0.0,    0.0);
```

*** MODELING OPTIONS USED: CONC RURAL FLAT   NOCALM

*** METEOROLOGICAL DAYS SELECTED FOR PROCESSING ***
(1=YES; 0=NO)

```
1111111111 1111111111 1111111111 1111111111 1111111111
1111111111 1111111111 1111111111 1111111111 1111111111
1111111111 1111111111 1111111111 1111111111 1111111111
1111111111 1111111111 1111111111 1111111111 1111111111
1111111111 1111111111 1111111111 1111111111 1111111111
1111111111 1111111111 1111111111 1111111111 1111111111
1111111111 1111111111 1111111111 1111111111 1111111111
1111111111 111111
```

NOTE: METEOROLOGICAL DATA ACTUALLY PROCESSED WILL ALSO DEPEND ON WHAT IS INCLUDED IN THE DATA FILE.

*** UPPER BOUND OF FIRST THROUGH FIFTH WIND SPEED CATEGORIES ***
(METERS/SEC)

1.54, 3.09, 5.14, 8.23, 10.80,

*** WIND PROFILE EXPONENTS ***

STABILITY CATEGORY	WIND SPEED CATEGORY 1	2	3	4	5	6
A	.70000E-01	.70000E-01	.70000E-01	.70000E-01	.70000E-01	.70000E-01
B	.70000E-01	.70000E-01	.70000E-01	.70000E-01	.70000E-01	.70000E-01
C	.10000E+00	.10000E+00	.10000E+00	.10000E+00	.10000E+00	.10000E+00
D	.15000E+00	.15000E+00	.15000E+00	.15000E+00	.15000E+00	.15000E+00
E	.35000E+00	.35000E+00	.35000E+00	.35000E+00	.35000E+00	.35000E+00
F	.55000E+00	.55000E+00	.55000E+00	.55000E+00	.55000E+00	.55000E+00

*** VERTICAL POTENTIAL TEMPERATURE GRADIENTS ***
(DEGREES KELVIN PER METER)

STABILITY CATEGORY	WIND SPEED CATEGORY 1	2	3	4	5	6
A	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00
B	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00
C	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00
D	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00
E	.20000E-01	.20000E-01	.20000E-01	.20000E-01	.20000E-01	.20000E-01
F	.35000E-01	.35000E-01	.35000E-01	.35000E-01	.35000E-01	.35000E-01

*** ISCST2 - VERSION 92062 ***   *** LAW ENVIRONMENTAL - BEALE AFB PROJ#2-123-2567-01 BIOVENTING   ***   08/21/92
***   ***   18:08:45
PAGE 6

*** MODELING OPTIONS USED: CONC RURAL FLAT   NOCALM

*** THE FIRST 24 HOURS OF METEOROLOGICAL DATA ***

FILE: beale1.met   FORMAT: (4I2,2F9.4,F6.1,I2,2F7.1)
SURFACE STATION NO.: 99999   UPPER AIR STATION NO.: 99999
NAME: SURFNAME   NAME: UAIRNAME
YEAR: 1990   YEAR: 1990

YEAR	MONTH	DAY	HOUR	FLOW VECTOR	SPEED (M/S)	TEMP (K)	STAB CLASS	MIXING HEIGHT (M) RURAL	URBAN
90	1	1	1	90.0	1.00	293.0	1	5000.0	5000.0
90	1	1	2	90.0	2.00	293.0	1	5000.0	5000.0
90	1	1	3	90.0	3.00	293.0	1	5000.0	5000.0
90	1	1	4	90.0	1.00	293.0	2	5000.0	5000.0
90	1	1	5	90.0	2.00	293.0	2	5000.0	5000.0
90	1	1	6	90.0	3.00	293.0	2	5000.0	5000.0
90	1	1	7	90.0	4.00	293.0	2	5000.0	5000.0
90	1	1	8	90.0	5.00	293.0	2	5000.0	5000.0
90	1	1	9	90.0	1.00	293.0	3	5000.0	5000.0
90	1	1	10	90.0	2.00	293.0	3	5000.0	5000.0
90	1	1	11	90.0	3.00	293.0	3	5000.0	5000.0
90	1	1	12	90.0	4.00	293.0	3	5000.0	5000.0
90	1	1	13	90.0	5.00	293.0	3	5000.0	5000.0
90	1	1	14	90.0	6.00	293.0	3	5000.0	5000.0
90	1	1	15	90.0	10.00	293.0	3	5000.0	5000.0
90	1	1	16	90.0	1.00	293.0	4	5000.0	5000.0
90	1	1	17	90.0	2.00	293.0	4	5000.0	5000.0
90	1	1	18	90.0	3.00	293.0	4	5000.0	5000.0
90	1	1	19	90.0	4.00	293.0	4	5000.0	5000.0
90	1	1	20	90.0	5.00	293.0	4	5000.0	5000.0
90	1	1	21	90.0	6.00	293.0	4	5000.0	5000.0
90	1	1	22	90.0	10.00	293.0	4	5000.0	5000.0
90	1	1	23	90.0	15.00	293.0	4	5000.0	5000.0
90	1	1	24	90.0	20.00	293.0	4	5000.0	5000.0

*** NOTES: STABILITY CLASS 1=A, 2=B, 3=C, 4=D, 5=E AND 6=F.
FLOW VECTOR IS DIRECTION TOWARD WHICH WIND IS BLOWING.

*** ISCST2 - VERSION 92082 *** *** LAW ENVIRONMENTAL - BEALE AFB PROJ#2-123-2567-01 BIOVENTING *** 08/21/92
*** *** 18:08:45
PAGE 7

*** MODELING OPTIONS USED: CONC RURAL FLAT NOCALM

*** THE 1ST HIGHEST 1-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 1 ,

*** DISCRETE CARTESIAN RECEPTOR POINTS ***

** CONC OF OTHER IN (MICROGRAMS/CUBIC-METER) **

X-COORD (M)	Y-COORD (M)	CONC	(YYMMDDHH)	X-COORD (M)	Y-COORD (M)	CONC	(YYMMDDHH)
25.00	0.00	5.36588	(90010104)	50.00	0.00	5.91924	(90010109)
75.00	0.00	5.88953	(90010116)	100.00	0.00	4.91909	(90010116)
150.00	0.00	3.09982	(90010116)	200.00	0.00	3.12266	(90010206)
250.00	0.00	2.97766	(90010206)	300.00	0.00	2.67175	(90010206)
400.00	0.00	2.05212	(90010206)	500.00	0.00	1.58086	(90010206)
750.00	0.00	0.91243	(90010206)	1000.00	0.00	0.60597	(90010206)
1500.00	0.00	0.33803	(90010206)	2000.00	0.00	0.22121	(90010206)
3000.00	0.00	0.12479	(90010206)				

*** ISCST2 - VERSION 92062 *** *** LAW ENVIRONMENTAL - BEALE AFB PROJ#2-123-2567-01 BIOVENTING *** 08/21/92
*** *** 18:08:45
PAGE 8

*** MODELING OPTIONS USED: CONC RURAL FLAT NOCALM

*** THE 2ND HIGHEST 1-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): 1 ,

*** DISCRETE CARTESIAN RECEPTOR POINTS ***

** CONC OF OTHER IN (MICROGRAMS/CUBIC-METER) **

X-COORD (M)	Y-COORD (M)	CONC	(YYMMDDHH)	X-COORD (M)	Y-COORD (M)	CONC	(YYMMDDHH)
25.00	0.00	4.92869	(90010101)	50.00	0.00	5.20209	(90010116)
75.00	0.00	4.10168	(90010109)	100.00	0.00	2.93974	(90010117)
150.00	0.00	2.69846	(90010208)	200.00	0.00	3.12266	(90010212)
250.00	0.00	2.97768	(90010212)	300.00	0.00	2.67175	(90010212)
400.00	0.00	2.05212	(90010212)	500.00	0.00	1.58086	(90010212)
750.00	0.00	0.91243	(90010212)	1000.00	0.00	0.60597	(90010212)
1500.00	0.00	0.33803	(90010212)	2000.00	0.00	0.22121	(90010212)
3000.00	0.00	0.12479	(90010212)				

```
*** ISCST2 - VERSION 92062 ***   *** LAW ENVIRONMENTAL - BEALE AFB PROJ#2-123-2567-01 BIOVENTING        ***      08/21/92
        ***                                                        ***     18:08:45
                                                                         PAGE  9
*** MODELING OPTIONS USED:  CONC   RURAL  FLAT                          NOCALM

                          *** THE SUMMARY OF HIGHEST  1-HR RESULTS ***

                       ** CONC OF OTHER    IN (MICROGRAMS/CUBIC-METER)              **

                                   DATE                                NETWORK
GROUP ID               AVERAGE CONC     (YYMMDDHH)        RECEPTOR  (XR, YR, ZELEV, ZFLAG)  OF TYPE  GRID-ID
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

ALL     HIGH  1ST HIGH VALUE IS     5.91924  ON 90010109: AT (    50.00,      0.00,     0.00,      0.00)  DC
        HIGH  2ND HIGH VALUE IS     5.20209  ON 90010116: AT (    50.00,      0.00,     0.00,      0.00)  DC

*** RECEPTOR TYPES:  GC = GRIDCART
                     GP = GRIDPOLR
                     DC = DISCCART
                     DP = DISCPOLR
                     BD = BOUNDARY
```

*** MODELING OPTIONS USED: CONC RURAL FLAT   NOCALM

*** Message Summary For ISC2 Model Execution ***

-------- Summary of Total Messages --------

A Total of   0 Fatal Error Message(s)
A Total of   0 Warning Message(s)
A Total of   0 Informational Message(s)

******** FATAL ERROR MESSAGES ********
*** NONE ***

******** WARNING MESSAGES ********
*** NONE ***

****
*** ISCST2 Finishes Successfully ***
****

APPENDIX B

TOXICOLOGICAL PROFILES

APPENDIX B: TOXICOLOGICAL PROFILES

Benzene

Benzene is a clear, volatile, colorless, highly flammable liquid with a characteristic odor. Benzene occurs naturally in many plants and animals, but is also a major industrial chemical made from coal and oil. In industry, benzene is used as a solvent and as a component of motor fuels such as gasoline. Because benzene evaporates very quickly, the most common exposure route for humans is through inhalation of contaminated air. Very small amounts of benzene are found in some foods and in contaminated drinking water. Benzene is also found in cigarette smoke. Benzene is absorbed into the blood stream from either the gastrointestinal tract, after ingestion, or the lungs, after inhalation. It is also absorbed through the skin, but at a very slow rate. After inhalation or ingestion exposure, humans and animals tend to eliminate benzene unchanged in the exhaled air or in a metabolized form in the urine and feces.

The principal acute toxic effect of benzene in humans and other animals is on the central nervous system, the blood making system and the immune system. Inhalation of high concentrations of benzene (i.e., 19,000 to 20,000 ppm for 5 to 10 minutes) may be fatal. Autopsies of persons who have died following inhalation of high concentrations of benzene have shown inflammation of the respiratory tract and damage to the lungs, kidneys, and brain, but no effect on the blood. Ingestion of high doses of benzene (i.e., 10 mL which has been reported as the lethal oral dose for humans) has produced symptoms of staggering gait, vomiting, shallow and rapid pulse, and loss of consciousness, followed by delirium, pneumonitis, collapse, and then sudden central nervous system (CNS) depression. Studies of chronic exposures to benzene by humans and animals have shown that benzene inhibits blood cell formation and can cause leukemia. There is also evidence for carcinogenicity. Benzene has been reported as being genotoxic, causing chromosome aberrations in the bone marrow cells of persons occupationally exposed to benzene. A relationship between benzene exposure and the development of leukemia has been reported in epidemiological studies (USEPA, 1988). Based on animal and epidemiological studies, benzene has been classified as a group A (known human) carcinogen by the USEPA.

The most significant source of benzene released to the environment is the combustion of gasoline. Benzene evaporates very easily from surface water or surface soils. Benzene is fairly soluble in water and can leach from soils into groundwater. Degradation of benzene can occur in the atmospheric by chemical degradation or in soil by biodegradation.

Ethylbenzene

Ethylbenzene is a clear, colorless liquid with a sweet, pungent, gasoline-like odor, and it occurs naturally in coal tar and petroleum. It evaporates at room temperature and burns easily. It is used as a solvent, a chemical intermediate and in many human-made products such as paints, inks, gasoline and insecticides. Exposure usually occurs by inhalation or dermal contact. Although information on metabolism is limited, it is believed that ethylbenzene is excreted in the urine.

Acute exposure to ethylbenzene results in liver, kidney and central nervous system effects. When inhaled, ethylbenzene irritates the eyes, nose, throat and lungs at concentrations of 200 ppm and above. In experimental animals, acute exposure to ethylbenzene has also resulted in nervous system depression followed by death due to respiratory center paralysis. No studies have reported death in humans following exposure to ethylbenzene. Chronic exposure to rodents of ethylbenzene results in liver and kidney effects. There have been no reports of developmental or reproductive effects in studies with experimental animals. The USEPA has classified ethylbenzene as a group D carcinogen indicating that it is not classifiable as to human carcinogenicity.

Ethylbenzene enters the atmosphere primarily from fugitive emissions and gasoline exhaust. In the air, it photochemically degrades, and is subject to rainout. In water, ethylbenzene is subject to biodegradation and evaporation, and has a half-life of several days to 2 weeks. Ethylbenzene has the potential to leach into groundwater, and it is moderately adsorbed by soil.

Toluene

Toluene is a clear, colorless liquid with a sweet odor. It is produced from three major sources, petroleum refining, as a by-product of styrene production, and as a by-product of coke oven operations. Toluene enters the body through inhalation, ingestion, or through dermal contact. It is rapidly absorbed through the lungs, in the gastrointestinal track and by the skin. Most of the toluene is removed from the body within 12 hours through the urine and expired air.

Acute and subacute inhalation exposures to toluene vapor result in symptoms of central nervous system toxicity. Animal studies indicate that oral acute toxicity is relatively low. Chronic exposures to toluene vapors have been associated primarily with central nervous system effects and, possibly, peripheral system effects. Liver and kidney functions are affected by chronic exposure to toluene as well. Reproductive effects and birth defects, including cleft palate, delayed skeletal development and fetotoxicity, have been reported (ATSDR, 1989). The USEPA classifies toluene as a group D carcinogen (not classifiable as to human carcinogenicity).

There is little tendency for toluene to persist in the environment; it readily decomposes in soil and evaporates rapidly. Toluene has a moderate tendency to bioaccumulate in fatty tissues of aquatic species.

Xylene

Xylene is a clear, colorless liquid with a sweet odor. Xylene is produced from four major sources; petroleum distillation, coal tar distillation, coal gas distillation and the organic chemical industry. It is also used in aviation gasoline, rubber cement, manufacturing solvents and protective coatings and synthesis of organic chemicals. Natural sources of xylene include coal tar and petroleum. Xylene is rapidly absorbed through the skin or through the lungs when inhaled. It is excreted from the body in the urine or is exhaled by the lungs.

In humans, short-term exposure to high levels of xylene has resulted in irritation to skin, eyes, nose and throat; difficulty in breathing; impaired function of the lungs; delayed response by the eyes; impaired memory; stomach discomfort; and possible changes in the liver and kidneys. Extended exposures (18 hours) to concentrations up to 10,000 ppm resulted in severe lung congestion, impairment of kidney function, liver damage and death. Chronic exposure of experimental animals to low doses of xylene (300 ppm) for 4 hours/day resulted in slight liver and lung effects. Xylene has been reported to produce developmental defects in chicken embryos. There are no available data on the carcinogenicity of xylene and the USEPA has a classified xylene as a group D carcinogen (not classifiable as to human carcinogenicity).

Most xylene that is released into the environment evaporates quickly to the atmosphere. However, it is moderately mobile in soil and can leach into the groundwater, where it may persist for several years. Xylene has been found to bioaccumulate very little.

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